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Laboratory Manual
of
General Chemistry

Williams

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LABORATORY MANUAL
OF
GENERAL CHEMISTRY.

INCLUDING

DIRECTIONS FOR PERFORMING ONE HUNDRED OF THE MORE
IMPORTANT EXPERIMENTS IN GENERAL CHEMISTRY AND
METAL ANALYSIS, WITH BLANKS AND A MODEL FOR
THE SAME, LABORATORY RULES AND SUGGES-
TIONS, AND TABLES OF ELEMENTS, COM-
POUNDS, SOLUTIONS, APPARA-
TUS, AND CHEMICALS.

*PREPARED FOR USE WITH ANY TEXT-BOOK OF CHEM-
ISTRY; SPECIALLY ADAPTED TO ACCOMPANY
"INTRODUCTION TO CHEMICAL SCIENCE."*

BY

R. P. WILLIAMS, A.M.,

INSTRUCTOR IN CHEMISTRY, ENGLISH HIGH SCHOOL, BOSTON, AND
AUTHOR OF "INTRODUCTION TO CHEMICAL SCIENCE."

BOSTON, U.S.A.:
GINN & COMPANY, PUBLISHERS.

1894.

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APPARATUS FOR EACH LOCKER.

[APPARATUS AND CHEMICALS CAN BE OBTAINED OF DR. A. P. GAGE,
BOSTON. "INTRODUCTION TO CHEMICAL SCIENCE" IS PUBLISHED
BY GINN & Co., BOSTON].

- 2 horseradish (or olive) bottles, and corks to fit.
- 1 soda bottle.
- 2 pieces window glass (3 in. sq.).
- 2 pieces glass tubing (20 in. long, $\frac{1}{4}$ in. diam.).
- 1 glass stirring-rod.
- 1 glass funnel (3 in., 60°).
- 1 piece ignition tubing (12 in. long, $\frac{1}{2}$ in. diam.).
- 1 porcelain evaporating dish (3 in. wide).
- 1 asbestos paper, or wire gauze (3 in. sq.).
- 1 iron (or tin) plate (5 or 6 in. diam.).
- 1 pair forceps.
- 1 three-cornered file.
- 1 round file ($\frac{3}{16}$ in.).
- 1 copper wire (15 in. long, No. 20).
- 6 test-tubes, and corks to fit.
- 1 wooden test-tube holder.
- 1 thistle-tube.

APPARATUS FOR GENERAL USE.

Flasks (200^{cc}).
Bunsen burners.
Rubber tubing (18 in. long, $\frac{1}{4}$ in. diam., inside).
Iron ring-stands.
Reagent bottles (250 and 500^{cc}).
Metric rulers (30^{cm} long).
Graduates (25^{cc} and 200^{cc}).
Scales with metric weights (1-100^g).
Pneumatic troughs.
Glass tubing ($\frac{1}{4}$ in. outside diam.).
Glass tubing ($\frac{3}{4}$ in. diam.).
Hessian crucibles (50 or 100^{cc}).
Beakers (25 or 50^{cc} and 1000^{cc}).
Lead trays (5 or 6^{cm} sq., 1 deep).
Mortars and pestles.
Fine wire gauze (No. 50 or 60, 4 in. sq.).
Platinum wire (No. 23).
Blow-pipes.
Bricks.

If all the pupils of a class work in the laboratory at the same time and on the same experiment, each should be supplied with a set of apparatus; if they work in divisions of say 10, 10 sets will be enough. This also applies to the "Apparatus for Each Locker."

CHEMICALS.

ESTIMATES FOR A CLASS OF TWENTY.

Acetic acid.....	2 lb.	Litmus paper.....	2 ft.
Alcohol.....	2 lb.	Magnesium chloride.....	2 oz.
Alum.....	4 oz.	Magnesium ribbon.....	2 ft.
Ammonium carbonate.....	2 oz.	Manganese chloride.....	2 oz.
Ammonium chloride.....	1 lb.	Manganese dioxide.....	1 lb.
Ammonium hydrate.....	4 lb.	Magnesium sulphate.....	1 oz.
Ammonium nitrate.....	1 lb.	Marble.....	2 lb.
Ammonium oxalate.....	2 oz.	Mercuric nitrate.....	2 oz.
Ammonium sulphate.....	4 oz.	Mercurous nitrate.....	2 oz.
Antimony (metallic).....	$\frac{1}{2}$ oz.	Molasses.....	1 pt.
Antimony chloride.....	2 oz.	Naphtha.....	1 lb.
Arsenic (metallic).....	$\frac{1}{2}$ oz.	Nitric acid.....	7 lb.
Arsenic teroxide.....	$\frac{1}{2}$ oz.	Nickel chloride.....	1 oz.
Barium chloride.....	3 oz.	Phosphorus.....	$\frac{1}{4}$ lb.
Barium nitrate.....	1 oz.	Picture wire.....	7 ft.
Beeswax.....	3 oz.	Potassium (metallic).....	$\frac{1}{8}$ oz.
Bi-carbonate of soda.....	2 oz.	Potassium bi-chromate.....	4 oz.
Bismuth nitrate.....	2 oz.	Potassium bromide.....	2 oz.
Bleaching-powder.....	$\frac{1}{2}$ lb.	Potassium chlorate.....	2 lb.
Bone-black.....	$\frac{1}{2}$ lb.	Potassium chromate.....	1 oz.
Brimstone.....	1 $\frac{1}{2}$ lb.	Potassium cyanide.....	1 oz.
Cadmium nitrate.....	2 oz.	Potassium ferrocyanide.....	2 oz.
Calcium chloride.....	2 oz.	Potassium hydrate.....	$\frac{1}{2}$ lb.
Calcium sulphate.....	1 oz.	Potassium iodide.....	2 oz.
Candles.....	—	Potassium nitrate.....	$\frac{1}{2}$ lb.
Cannel coal.....	$\frac{1}{2}$ lb.	Potassium nitrite.....	2 oz.
Carbon bisulphide.....	2 oz.	Silver nitrate.....	1 oz.
Charcoal.....	$\frac{1}{2}$ lb.	Soap.....	$\frac{1}{4}$ lb.
Cobalt chloride.....	$\frac{1}{2}$ oz.	Sodium (metallic).....	$\frac{1}{4}$ oz.
Cochineal.....	$\frac{1}{4}$ oz.	Sodium arsenite.....	2 oz.
Coins.....	—	Sodium carbonate.....	1 lb.
Copper (filings or turnings).....	1 lb.	Sodium chloride.....	1 lb.
Copper nitrate.....	3 oz.	Sodium hydrate.....	1 lb.
Copper oxide.....	2 oz.	Sodium hyposulphite.....	$\frac{1}{4}$ lb.
Chlorhydric acid.....	10 lb.	Sodium nitrate.....	$\frac{1}{2}$ lb.
Ferrous sulphate.....	4 oz.	Sodium sulphide.....	$\frac{1}{4}$ lb.
Ferrous sulphide.....	3 lb.	Sodium sulphite.....	1 oz.
Filter papers (4 in.).....	1000	Sodium phosphate.....	3 oz.
Fluor spar (powdered).....	3 oz.	Starch.....	$\frac{1}{2}$ lb.
Fuming sulphuric acid.....	$\frac{1}{2}$ lb.	Strontium chloride.....	1 oz.
Gold leaf.....	4 in. sq.	Sugar.....	$\frac{1}{2}$ lb.
Indigo.....	1 oz.	Sulphuric acid.....	12 lb.
Iodine.....	$\frac{1}{2}$ oz.	Tin chloride.....	2 oz.
Lead.....	$\frac{1}{2}$ lb.	Turkey red cloth.....	$\frac{1}{2}$ yd.
Lead acetate.....	2 oz.	Turpentine (spirits).....	1 oz.
Lead nitrate.....	$\frac{1}{2}$ lb.	Water glass.....	1 lb.
Lead protoxide.....	1 oz.	Yeast.....	1 cake
Lime (unslaked).....	1 lb.	Zinc.....	1 lb.
Litmus.....	1 oz.	Zinc chloride.....	2 oz.

RULES AND SUGGESTIONS FOR THE LABORATORY.

1. Each pupil must furnish a cloth or sponge to keep his table clean, and any apron or other clothing desired for use in the laboratory. These latter are indispensable for preserving the clothing.

2. The table occupied by pupils must be left clean and dry after every laboratory exercise. Wash and wipe dry a ring stand, or any other apparatus on which a reagent has fallen, wipe out a p.t. after using it, and keep reagent bottles, other apparatus, books, and lockers clean.

3. Pupils are held responsible for apparatus, and must replace anything that is broken or lost.

4. Have every d.t. and stopper fit tightly, to prevent leakage of gas. If a gas generates well but does not pass into the receptacle, there is some leakage, due probably to loose bearings.

5. In heating a t.t. on the r.s., hold the lamp in the hand, moving it slowly.

6. Mixtures of solids should be made on paper or in an e.d. Be careful not to mix chemicals or reagents except as directed.

7. To shake the contents of a t.t., cover its mouth with the thumb or the hand, hold it away from the table, and shake it vigorously.

8. Never put down a stopper when using a reagent bottle, but hold it between the first and second fingers, and replace it as soon as you are through using it. Do not pour back any excess of a reagent from a t.t. or other rec. into a reagent bottle, and do not dip a stirring-rod into a reagent bottle.

9. In pouring a liquid into a graduate or t.t., hold the latter on a level with the eye, placing the thumb-nail at the upper limit to which it is desired the liquid should reach.

10. Pour only liquids or fine powders into the bowls, always opening the jet at first, to let the water run. Solids should be thrown into the jars.

11. Have flasks and t.t. perfectly dry on the outside before applying heat. If there are no racks for t.t., they may conveniently rest in the rec. when not in use.

12. Reagents for general use must not be taken to the individual's table, but must be left at the side-table.

13. In experimenting, follow the directions as closely as possible. Read an exp. through before performing any part of it. Ask an explanation of anything you do not understand.

14. Read the "Model for Taking Notes." Begin to write your notes on the page opposite the exp. Both name and symbolize substances once in each exp.; as, manganese dioxide, MnO_2 . After that use the symbols only. In writing equations, use only symbols. If a symbol or a name is not intelligible, refer to the table of "Symbols and Names."

15. In memorizing exps., learn names, symbols, processes, products, and reactions. Do not try to remember quantities.

16. Try to enter into the spirit of the work, by making close observations, and ascertaining what each exp. teaches. Always state whether heat has to be applied, whether the action is vigorous, and what is the color and what the state of the product.

17. No notes are to be written in this book outside of the laboratory, without special permission. Books must be brought to the teacher for inspection after each exp., and must be left in the laboratory at the end of the hour. No other books are to be used in the laboratory.

18. With the book closed, write your name and the division to which you belong distinctly across the front edge, in Roman letters.

19. For burns, put some dried Na_2CO_3 or HNaCO_3 on a handkerchief, moisten it, and bind it on the part affected. If taken in season no blister need occur, and the pain is soon allayed.

MODEL FOR TAKING NOTES.

49. TO MAKE NITROGEN PROTOXIDE.

I led a d.t. from a flask to a large t.t. immersed in water, and from this another d.t. to a p.t.

I put into the flask 10g ammonium nitrate, NH_4NO_3 , and heated.

At first the NH_4NO_3 melted, then a gas appeared to come off. A liquid collected in the bottle. This I found to be neutral to litmus, but it tasted like NH_4NO_3 . I concluded it was water and NH_4NO_3 . A colorless gas collected in the rec. over water. It was nitrogen protoxide, N_2O .

NH_4NO_3 had been separated into H_2O and N_2O .

$\text{NH}_4\text{NO}_3 = 2 \text{H}_2\text{O} + \text{N}_2\text{O}$.

ABBREVIATIONS.

ap. — Apparatus.	i.t. — Ignition tube.
cc. — Cubic centimeter.	lit. — Litmus paper.
ch. — Chemicals.	ppd. — Precipitated.
cm. — Centimeter.	ppn. — Precipitation.
def. sp. — Deflagrating spoon.	ppt. — Precipitate.
dil. — Dilute.	p.t. — Pneumatic trough.
down. disp. — Downward displacement.	rec. — Receiver.
d.t. — Delivery tube.	r.s. — Ring stand.
e.d. — Evaporating dish.	sat. — Saturated.
exp. — Experiment.	sol. — Solution (aqueous).
g. — Gram.	st.r. — Stirring rod.
gen. — Generator.	t.t. — Test tube.
	up. disp. — Upward displacement.

TABLE OF ELEMENTS.

	NAME.	SYM.	VAL.	AT. WT.	V.D.	STATE.
Negative or Non-metallic Elements. Acid-forming with H (usually OH).	Oxygen	O	II	16	16	G
	Sulphur	S	II, IV, (VI)	32	32	S
	Nitrogen	N	(I), III, V	14	14	G
	Fluorine	F	I, (V)	19		G
	Chlorine	Cl	I, (V)	35.5	35.5	G
	Bromine	Br	I, (V)	80	80	L
	Iodine	I	I, (V)	127	127	S
	Phosphorus	P	(I), III, V	31	62	S
	Arsenic	As	III, V	75	150	S
	Carbon	C	(II), IV	12		S
	Antimony	Sb	III, V	122		S
	Silicon	Si	IV	28		S
	Hydrogen	H	I	1	1	G
	Gold	Au	(I), III	196		S
	Platinum	Pt	(II), IV	197		S
	Mercury	Hg	I, II	200	100	L
Positive or Metallic Elements. Base-forming with OH.	Silver	Ag	I	108		S
	Copper	Cu	I, II	63		S
	Tin	Sn	II, IV	118		S
	Lead	Pb	II, IV	206		S
	Iron	Fe	II, IV, (VI)	56		S
	Zinc	Zn	II	65	32½	S
	Manganese	Mn	II, IV, VI	55		S
	Aluminium	Al	(II), IV	27		S
	Magnesium	Mg	II	24		S
	Calcium	Ca	II	40		S
	Barium	Ba	II	137		S
	Sodium	Na	I	23		S
	Potassium	K	I	39		S

SYMBOLS AND NAMES.

<i>Symbols.</i>	<i>Chemical Names.</i>	<i>Common Names.</i>
Ag_2Br	Argentous bromide.	
AgBr	Argentive bromide.....	Bromide of silver.
Ag_2Cl	Argentous chloride.	
AgCl	Argentive chloride.....	Chloride of silver.
AgNO_3	Argentive nitrate.....	Nitrate of silver.
Ag_2S	Argentive sulphide.	
$\text{Al}_3(\text{NO}_3)_6$	Aluminic nitrate.	
$\text{Al}_2(\text{OH})_6$	Aluminic hydrate.	
AsCl_3	Arsenious chloride.	
As_2O_3	Arsenious oxide	White arsenic.
As_2S_3	Arsenious sulphide.	
AuCl_3	Auric chloride.....	Chloride of gold.
$\text{Ba}(\text{C}_2\text{H}_3\text{O}_2)_2$	Barium acetate.	
BaCl_2	Barium chloride.	
BaCrO_4	Barium chromate.	
BaCO_3	Barium carbonate.	
$\text{Ba}(\text{NO}_3)_2$	Barium nitrate.	
BaSO_4	Barium sulphate.	
$\text{Bi}(\text{NO}_3)_3$	Bismuthous nitrate.	
$\text{Bi}(\text{OH})_3$	Bismuthous hydrate.	
Bi_2S_3	Bismuthous sulphide.	
$\text{C}_{10}\text{H}_{16}$	Turpentine (hydrocarbon) ...	Spirits of turpentine.
$\text{C}_6\text{H}_{10}\text{O}_5$	Starch (carbohydrate).	
$\text{C}_{12}\text{H}_{22}\text{O}_{11}$	Sucrose (carbohydrate).....	Sugar.
$\text{C}_{18}\text{H}_{30}\text{O}_{15}$	Cellulose (carbohydrate)....	Woody fibre.
$\text{C}_2\text{H}_5\text{OH}$	Ethyl hydrate.....	Alcohol.
CO	Carbon protoxide.....	Carbonic oxide.
CO_2	Carbon dioxide.....	Carbonic acid gas.
CS_2	Carbon disulphide.....	Bisulphide of carbon.
$\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2$	Calcium acetate.	
CaC_2O_4	Calcium oxalate.	
CaCO_3	Calcium carbonate.....	Carbonate of lime.
CaCl_2	Calcium chloride.	
$\text{Ca}(\text{ClO})_2$	Calcium hypochlorite	In bleaching powder.
CaF_2	Calcium fluoride.....	Fluor spar.
CaO	Calcium oxide	Unslaked lime.
$\text{Ca}(\text{OH})_2$	Calcium hydrate	Slaked lime.
CaSO_4	Calcium sulphate.....	Sulphate of lime.

<i>Symbols.</i>	<i>Chemical Names.</i>	<i>Common Names.</i>
$\text{Cd}(\text{NO}_3)_2$	Cadmium nitrate.	
CdS	Cadmium sulphide.	
$\text{Co}(\text{C}_2\text{H}_3\text{O}_2)_2$	Cobaltous acetate.	
CoCl_2	Cobaltous chloride.	
$\text{Co}(\text{OH})_2$	Cobaltous hydrate.	
CoS	Cobaltous sulphide.	
Cr_2Cl_6	Chromic chloride.	
$\text{Cr}_2(\text{NO}_3)_6$	Chromic nitrate.	
$\text{Cr}_2(\text{OH})_6$	Chromic hydrate.	
CuCl_2	Cupric chloride.	
$\text{Cu}(\text{NO}_3)_2$	Cupric nitrate.	
CuO	Cupric oxide.	Black copper oxide.
CuS	Cupric sulphide.	
CuSO_4	Cupric sulphate.	Blue vitriol.
$\text{Cu}_2\text{Fe}(\text{CN})_6$	Cupric ferrocyanide.	
FeCl_2	Ferrous chloride.	
$\text{Fe}_2(\text{NO}_3)_6$	Ferric nitrate.	
Fe_3O_4	Ferric tetroxide.	Magnetic oxide.
$\text{Fe}(\text{OH})_2$	Ferrous hydrate.	
$\text{Fe}_2(\text{OH})_6$	Ferric hydrate.	
FeS	Ferrous sulphide.	Sulphide of iron.
FeSO_4	Ferrous sulphate.	Copperas.
$(\text{FeSO}_4)_2\text{NO}$	Nitrosyl ferrous sulph.	
$\text{Fe}_2(\text{SO}_4)_3$	Ferric sulphate.	
$\text{HC}_2\text{H}_3\text{O}_2$	Acetic acid.	Found in vinegar.
$\text{H}_2\text{C}_4\text{H}_4\text{O}_6$	Tartaric acid.	
H_2CO_3	Carbonic acid.	
HCl	Chlorhydric acid.	Muriatic acid.
HClO	Hypochlorous acid.	
HF	Fluorhydric acid.	
HKSO_4	Hydrogen pot. sulphate.	Acid pot. sulphate.
HNO_3	Nitric acid.	Aqua fortis.
HNaCO_3	Hydrogen sod. carbonate.	Bicarbonate of soda.
HNa_2PO_4	Hyd. disodium phosphate.	Sodic phosphate.
HNaSO_4	Hyd. sodium sulphate.	Acid sod. sulphate.
H_2O	Hyd. oxide.	Water.
H_2S	Hyd. sulphide.	Sulphuretted hydrogen.
H_2SO_3	Sulphurous acid.	
H_2SO_4	Sulphuric acid.	Oil of vitriol.
$\text{H}_2\text{S}_2\text{O}_7$	Fuming sulph. acid.	Nordhausen acid.
H_4SiO_4	Silicic acid.	
HgCl	Mercurous chloride.	Calomel.
HgCl_2	Mercuric chloride.	Corrosive sublimate.
HgNO_3	Mercurous nitrate.	
$\text{Hg}(\text{NO}_3)_2$	Mercuric nitrate.	
HgS	Mercuric sulphide.	
$\text{K}_2\text{Al}_2(\text{SO}_4)_4$	Potassium alumin. sulphate.	Alum.
KBr	Potassium bromide.	Bromide of potash.
KCl	Potassium chloride.	

<i>Symbols.</i>	<i>Chemical Names.</i>	<i>Common Names.</i>
KClO ₃	Potassium chlorate.....	Chlorate of potash.
KCN.....	Potassium cyanide.	
K ₂ Co ₂ (NO ₂) ₁₂	Potassium cobaltic nitrite.	
K ₂ CrO ₄	Potassium chromate.	
K ₂ Cr ₂ O ₇	Potassium dichromate.....	Bichromate of potash.
K ₄ Fe(CN) ₆	Potassium ferrocyanide.....	Yellow prussiate of pot.
KI.....	Potassium iodide.	
KNO ₂	Potassium nitrite.	
KNO ₃	Potassium nitrate.....	Saltpetre, nitre.
K ₂ O.....	Potassium oxide.	
KOH.....	Potassium hydrate.....	Caustic potash.
K ₂ SO ₄	Potassium sulphate.	
K ₄ SiO ₄	Potassium silicate.....	Water glass.
MgCl ₂	Magnesium chloride.	
Mg(NH ₄) ₂ (CO ₃) ₂ ...	Magnesium ammonium carb.	
Mg ₃ (PO ₄) ₂	Magnesium phosphate.	
MgSO ₄	Magnesium sulphate.....	Epsom salt.
MgO.....	Magnesium oxide.	
MnCl ₂	Manganous chloride.	
Mn(OH) ₂	Manganous hydrate.	
MnO ₂	Manganic oxide.....	Black manganese oxide.
MnS.....	Manganous sulphide.	
MnSO ₄	Manganous sulphate.	
(NH ₄) ₃ (AgCl) ₂ ...	Ammonio-argentic chloride.	
(NH ₄) ₃ AsO ₃	Ammonium arsenite.	
(NH ₄) ₃ AsS ₃	Ammonium sulpharsenite.	
NH ₄ C ₂ H ₃ O ₂	Ammonium acetate.	
(NH ₄) ₂ CO ₃	Ammonium carbonate.	
(NH ₄) ₂ C ₂ O ₄	Ammonium oxalate.	
NH ₄ Cl.....	Ammonium chloride.....	Sal ammoniac.
NH ₂ Hg ₂ Cl.....	Amido-mercurous chloride.	
NH ₄ MgAsO ₄	Ammon. magnes. arseniate.	
NH ₄ MgPO ₄	Ammon. magnes. phosphate.	
NH ₄ NO ₃	Ammon. nitrate.	
NH ₄ OH.....	Ammon. hydrate.....	Aqua ammonia.
(NH ₄) ₂ S.....	Ammon. sulphide.	
(NH ₄) ₂ SO ₄	Ammon. sulphate.	
N ₂ O.....	Nitrogen protoxide.....	Nitrous oxide.
NO or N ₂ O ₂	Nitrogen dioxide.....	Nitric oxide.
NO ₂ or N ₂ O ₄	Nitrogen tetroxide.....	Nitrogen peroxide.
NOCl.....	Nitrosyl chloride.....	Nitrogen oxychloride
Na ₂ Al ₂ O ₄	Sodium aluminate.	
Na ₃ AsO ₃	Sodium arsenite.	
Na ₂ CO ₃	Sodium carbonate.....	Carbonate of soda.
NaCl.....	Sodium chloride.....	Common salt.
Na ₂ CrO ₄	Sodium chromate.	
NaNO ₃	Sodium nitrate.....	Chili saltpetre.
Na ₂ O.....	Sodium oxide.	
NaOH.....	Sodium hydrate.....	Caustic soda.

<i>Symbols.</i>	<i>Chemical Names.</i>	<i>Common Names.</i>
Na_2S	Sodium sulphide.	
Na_2SO_3	Sodium sulphite.	
Na_2SO_4	Sodium sulphate.....	Glauber's salt.
$\text{Na}_2\text{S}_2\text{O}_3$	Sodium thiosulphate.....	Hyposulphite of sod.
Na_4SiO_4	Sodium silicate.....	Water glass.
Na_2ZnO_2	Sodium zincate.	
$\text{Ni}(\text{C}_2\text{H}_3\text{O}_2)_2$	Nickelous acetate.	
NiCl_2	Nickelous chloride.	
$\text{Ni}(\text{OH})_2$	Nickelous hydrate.	
NiS	Nickelous sulphide.	
P_2O_3	Phosphorus trioxide.	
P_2O_5	Phosphorus pentoxide.	
PbBr_2	Lead bromide.	
$\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$	Lead acetate.....	Sugar of lead.
PbCO_3	Lead carbonate.....	White lead.
$\text{Pb}(\text{CN})_2$	Lead cyanide.	
PbCl_2	Lead chloride.	
PbCrO_4	Lead chromate.....	Chrome yellow.
$\text{Pb}_2\text{Fe}(\text{CN})_6$	Lead ferrocyanide.	
PbI_2	Lead iodide.	
$\text{Pb}(\text{NO}_3)_2$	Lead nitrate.	
PbO	Lead oxide.....	Litharge.
$\text{Pb}(\text{OH})_2$	Lead hydrate.	
PbS	Lead sulphide.	
PbSO_3	Lead sulphite.	
PbSO_4	Lead sulphate.	
SO_2	Sulphur dioxide.....	Sulphurous acid.
SbCl_3	Antimonious chloride.	
Sb_2O_3	Antimonious oxide.	
SbOCl	Antimonyl chloride.	
$(\text{SbO})_2\text{C}_4\text{H}_4\text{O}_6$	Antimonyl tartrate.	
Sb_2S_3	Antimonious sulphide.	
SiF_4	Silicic fluoride.	
SiO_2	Silicic oxide.....	Silica, quartz, sand.
SnCl_2	Stannous chloride.	
SnCl_4	Stannic chloride.	
$\text{Sn}_3(\text{PO}_4)_2$	Stannous phosphate.	
SnS	Stannous sulphide.	
SnS_2	Stannic sulphide.	
$\text{Sn}_2(\text{SO}_4)_3$	Stannic sulphate.	
$\text{Sr}(\text{C}_2\text{H}_3\text{O}_2)_2$	Strontium acetate.	
SrCO_3	Strontium carbonate.	
SrCl_2	Strontium chloride.	
SrSO_4	Strontium sulphate.	
$\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2$	Zincic acetate.	
ZnCl_2	Zincic chloride.	
$\text{Zn}(\text{NO}_3)_2$	Zincic nitrate.	
ZnS	Zincic sulphide.	
ZnSO_4	Zincic sulphate.....	White vitriol.

SOLUTIONS FOR REAGENTS AND ANALYSIS.

—••—

NUMBER OF GRAMS OF SOLIDS TO 500^{cc} OF H₂O.

These solutions should be prepared (with distilled water preferably), filtered if necessary, and placed on shelves or a side-table for class use.

AgNO ₃25	Hg(NO ₃) ₂10	NaNO ₃20
BaCl ₂50	K ₂ Al ₂ (SO ₄) ₄50	NaOH.....60
Ba(NO ₃) ₂30	KBr.....25	Na ₂ S20
Bi(NO ₃) ₃10	KCN50	Na ₂ SO ₃100
C ₁₂ H ₂₂ O ₁₁sat.	K ₂ CrO ₄50	Na ₂ S ₂ O ₃sat.
CaCl ₂60	K ₂ Cr ₂ O ₇50	NH ₄ Cl.....60
Ca(OH) ₂sat.	K ₄ Fe(CN) ₆40	(NH ₄) ₂ C ₂ O ₄20
CaSO ₄sat.	KI25	NH ₄ NO ₃50
Cd(NO ₃) ₂10	KNO ₂50	(NH ₄) ₂ SO ₄5
CoCl ₂10	KNO ₃50	NiCl ₂10
CuCl ₂50	KOH.....60	Pb(C ₂ H ₃ O ₂) ₂50
Cu(NO ₃) ₂50	MgCl ₂50	Pb(NO ₃) ₂100
FeSO ₄ *.....50	MgSO ₄50	SnCl ₂ †.....40
HNaCO ₃50	MnCl ₂50	SrCl ₂50
HNa ₂ PO ₄42	Na ₃ AsO ₃ †.....60	SbCl ₃ †.....5
HgCl ₂30	NaCl50	ZnCl ₂10
HgNO ₃ 25 + 25 ^{cc} NHO ₃	Na ₂ CO ₃50	

(NH₄)₂CO₃ 100g, H₂O 400^{cc}, NH₄OH 100^{cc}.

(NH₄)₂S. Pass H₂S through NH₄OH (diluted as below) till the sol. gives no ppt. with MgSO₄ sol.

Cochineal sol. is prepared by pulverizing 6g cochineal insects and covering for several days with a mixture of 400^{cc} H₂O and 100^{cc} alcohol, then filtering.

Litmus sol. is prepared by heating for several hours over a water.

*Prepare only as wanted.

† Acidulate with HCl.

bath, 80% of pulverized litmus in 500^{cc} of water, replacing the water as it evaporates, then filtering. Keep the sol. in an open bottle.

Indigo sol. (sulphindigotic acid) is made by slowly mixing and stirring 5g indigo with 25^{cc} $\text{H}_2\text{S}_2\text{O}_7$ (fuming sulphuric acid) in a beaker immersed in cold water. Cover the beaker, and after 48 hours add 500^{cc} H_2O ; stir and filter.

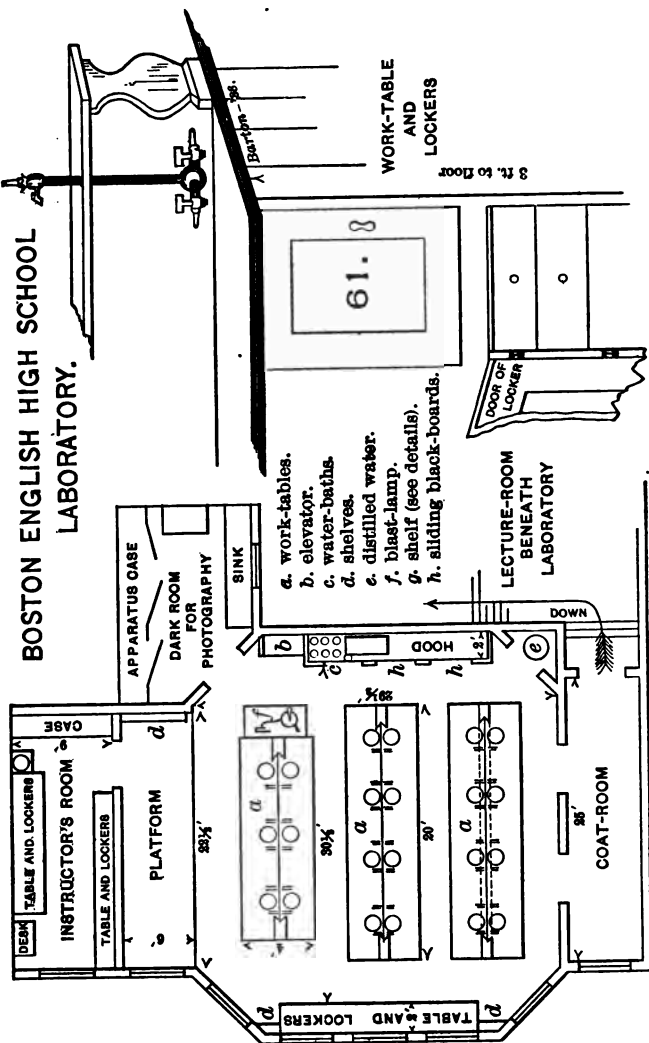
Dilute acids are made by mixing one volume of the acid with four volumes of water. NH_4OH should be diluted with three times its volume of water before using.

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BOSTON ENGLISH HIGH SCHOOL LABORATORY.



1. LENGTH.

[Read RULES AND SUGGESTIONS.]

Ap. : metric ruler, 30^{cm} long, test-tube.

1. Note the length of 10^{cm} on a metric ruler.
2. Estimate by the eye alone this distance on the cover of a book.
3. Verify the result.
4. Estimate the same on a t.t., and verify.
5. Try with different objects till you carry in mind 10^{cm}.
6. Estimate the number of inches it covers, and verify.
7. In the same way experiment with 1^{cm}.
8. Measure the perpendicular distance between the blue lines of foolscap.
9. Measure the diameter of the *old* nickel five-cent piece.
10. Measure and estimate in the same way 5^{cm}.
11. Make a drawing of these measurements on the opposite page: one square decimeter, *i.e.* 10^{cm} on a side; 1^{cm}.



2. VOLUME.

Ap. : graduate holding 25 or 50^{cc}.

1. Into a graduate put 10^{cc} of water, then pour it into a t.t.
2. Note, without marking, what proportion of the t.t. is filled. Make a drawing of it on the opposite page.
3. Pour out the water, then put into the t.t. the same quantity, estimating it by the eye alone.
4. Verify the result by pouring the water into the graduate.
5. Repeat this till you can estimate quite accurately.
6. Try it with a t.t. of another size.
7. Estimate 1^{cc} of a liquid in a similar way.
8. Estimate also 5^{cc}.
9. Draw figures of a graduating glass, and of a cube 1^{cm} on a side.
10. In subsequent experiments estimate volumes, without measuring, unless special accuracy is required.

3. WEIGHT.

Ap. : pair of scales, 1, 5, 10^g weights.

Ch. : 50^g fine salt.

1. Balance a piece of paper on each pan of a pair of scales.
2. On one pan put a 10^g weight, and balance this with fine salt.
3. Note with the eye the quantity of salt, then remove it.
4. Now estimate the same quantity, and verify by weighing it.
5. Repeat the experiment several times.
6. Weigh 1^g and estimate as before.
7. See if 1^g can be piled on a one-cent coin.
8. Experiment with 5^g in a like way.
9. Make drawings of 1, 5, and 10^g weights.
10. In subsequent experiments estimate quantities of solids, unless accuracy is desired.



4. THE MOLECULAR STATE.

Ap. : Bunsen burner (or alcohol lamp), two test-tubes,
funnel, filter paper.

Ch. : 2^g sugar.

[*Read* RULE 17.]

1. Put into a t.t. 2^g sugar, $C_{12}(H_2O)_{11}$, and cover it with 5^{cc} H_2O .
2. Boil it in a Bunsen flame for a minute, using the wooden test-tube holder, till the sugar disappears.
3. When cool, taste a drop of the liquid.
4. Arrange a filter paper and filter the liquid, catching the filtrate in another t.t.
5. Touch a drop of the filtrate to the tongue. Has the sugar gone through the filter paper?
6. Pour out half of the liquid, and save the rest for Exp. 5.
7. Take full notes of this experiment and all subsequent ones, describing what you do, what you see, and what you infer. Read the "Model for Taking Notes."



5. ELEMENTS AND THE ATOMIC STATE.

Ap. : test-tube.

Ch. : sugar solution, 3rd sulphuric acid.

1. To the remainder of the sol., Exp. 4, slowly add an equal volume of H_2SO_4 .
2. If the color is unchanged, add more.
3. Notice whether the temperature of the t.t. increases.
4. Observe any change of color, volume, and state, in the product.
5. Clean the t.t. with water.
6. Explain the phenomena, stating the action of H_2SO_4 on sugar. Is it a physical or a chemical change, and why?



6. CHEMICAL UNION.

Ap. : piece of ignition tubing (15^{cm} long, 1^{cm} diam.), lamp.

Ch. : 2^g brimstone, 1^g Cu turnings.

1. Mix well on paper 2^g S (brimstone, coarsely powdered) and the same *bulk* of Cu turnings, and put into a small i.t., made by drawing out a glass tube in the flame.
2. Hold the mixture in the flame till the substance becomes red hot throughout.
3. Break the tube with a jet of water and examine the contents. See whether they resemble either S or Cu. Describe the appearance.
4. Among the other notes write the equation for the chemical change, *and explain it*. Omit atomic and molecular weights in the laboratory.

7. TO PREPARE APPARATUS.

Ap. : lamp, round file, glass tubing (50^{cm} long, $\frac{1}{4}$ in. diam.),
2 corks.

1. Bend a piece of glass tubing about 8^{cm} from the end by holding it *lengthwise* of an ordinary gas flame, which should not be more than 5^{cm} across. In doing this hold each end of the glass between the first and second fingers and the thumb; rotate it slowly from you with the thumb and forefinger of the right hand, holding it steadily in the flame until it yields; then, without twisting, bend the ends at right angles towards you. Make another bend 6 or 8^{cm} from the first, holding the tubing by the ends, keeping it constantly in the flame, and slowly rotating it without twisting; while making this bend turn the glass so as to look lengthwise of it, and have the three parts lie in the same plane. *Avoid having the heated glass come in contact with any cool surface.*
2. Make other bends. Show your results to the instructor and, if approved, prepare one or more d.t., 40 or 50^{cm} long, as in the models, which must first be carefully examined as to the length of each part and the angles. Make the bends in the order directed.
3. With a round file bore a small hole in a cork, taking care to have it perpendicular to the faces of the cork. It must be *perfectly circular*, and a little smaller than the d.t. which it is to receive.



8. TO MAKE OXYGEN.

[Read RULES 2, 4, 5, 6.]

Ap. : r.s., lamp, p.t., t.t., d.t., 4 rec.

Ch. : 5^s KClO₃, 4^s MnO₂.

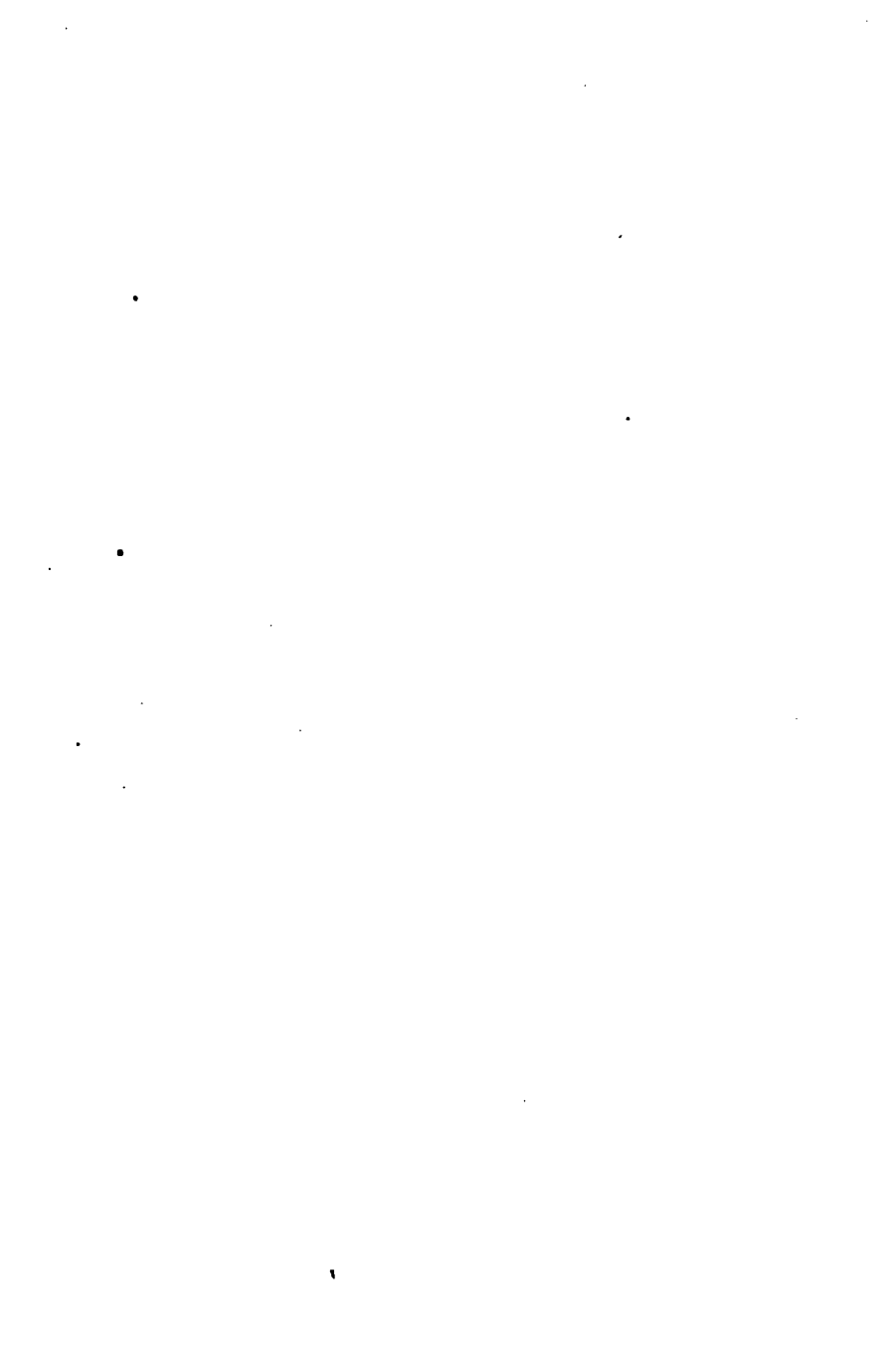
1. Mix 5^s KClO₃ with 3 or 4^s of fine MnO₂. Do not pulverize the KClO₃.
2. Put the mixture into a large t.t., which should not be over half-full.
3. Adjust a stopper and d.t., and hang the apparatus on a r.s., having the end of the d.t. in a p.t.
4. Fill four wide-mouthed bottles with H₂O, and invert them on the shelf of the p.t., with water 1 or 2^{cm} above the shelf.
5. Put a flame against the t.t., holding the lamp and slowly moving it. Avoid heating too long in one place.
6. Catch the escaping gas in the inverted rec.
7. Take out the end of the d.t. from the p.t., as soon as the lamp is removed, to prevent the water from drawing back.
8. Remove the rec. when full, keeping them covered with glass plates.
9. After making exps. 9, 10, 11, 12, clean the t.t. by covering the residue with water, closing the mouth of the t.t. with the thumb, and shaking the contents vigorously, away from the table.
10. Notes and equation. KClO₃ = ?



9. TO BURN CARBON IN OXYGEN.

Ch. : rec. of O, splinter.

1. Put a burning stick into a rec. of O, and notice the combustion.
2. Remove, blow out the flame, and put in the stick again while red hot. Describe the result. Repeat this till there is no longer any effect.
3. Wood consists mostly of C and of H. $C + 2 O = ?$
 $2 H + O = ?$ Omit the *explanation* of equations except where called for.



10. TO BURN SULPHUR IN OXYGEN.

Ap.: Cu wire, piece of crayon (3" long), lamp.

Ch.: rec. of O, piece of S (size of a pea).

1. Hollow out the end of a crayon or an electric-light pencil, and attach a Cu wire for a deflagrating spoon.
2. Put into it a bit of S, hold in the flame till the S burns, then lower it into a rec. of O. Notice the color and vigor of the flame.
3. When combustion ceases, remove the wire and cautiously take the odor.
4. $S + 2 O = ?$ Mention the color, state, odor, and name of the product.

11. TO BURN PHOSPHORUS IN OXYGEN.

Ap. : forceps, def. sp. (wire and crayon), wire, lamp.

Ch. : piece of P (size of half a pea), rec. of O.

1. With the forceps put into a def. sp. a bit of P, half as large as a pea, after first drying it with paper.
2. Heat one end of a wire or some metal, touch the P with it, and lower the P at once into a rec. of O.
3. When combustion ceases, remove and burn every bit of the P by holding it in a flame.
4. Describe the flame and the product. $2\text{P} + 5\text{O}$
 $\text{—? } 2\text{P} + 3\text{O} \text{—?}$

12. TO BURN IRON IN OXYGEN.

Ap. : lamp, e.d.

Ch. : rec. of O, little S, picture-cord wire (10^{cm} long).

1. With forceps hold one end of a picture-cord wire, or a steel shaving, 5 or 10^{cm} long, in a flame for an instant, then dip it into a bit of powdered S.
2. Hold it again in the flame till the S burns, then put it into a rec. of O, with a little H₂O in the bottom.
3. If the Fe does not burn, repeat with another rec. Have but little S on the wire. $3\text{Fe} + 4\text{O} = ?$

13. TO SEPARATE NITROGEN.

Ap. : e.d., p.t., def. sp., rec. and glass, forceps, wire, lamp.

Ch. : piece of P (half the size of a pea).

1. Fill a p.t. with water to 1 or 2^{cm} above the shelf.
2. Prepare a def. sp. with the wire bent sharply 5 or 6^{cm} from the bowl of the spoon.
3. Pass the wire through the orifice in the shelf of the p.t., fasten it there, and invert a rec. or small graduate over it, so as to seal the mouth under water. When easily adjustable, remove the rec., leaving the wire.
4. Using forceps and e.d., dry a piece of P (size of half a pea) on paper, and put it into the spoon.
5. Touch it with a hot wire or the handle of a file, and instantly invert the rec. over it as before. Hold the rec. steadily with the hand till combustion ceases.
6. Before removing the def. sp. be sure that combustion has stopped, and let no air enter.
 $2\text{P} + 5\text{O} = ?$ $2\text{P} + 3\text{O} = ?$
7. Finally remove the spoon, without admitting air or disturbing the rec.
8. Burn the P and leave the rec. till the gas becomes tolerably clear; then remove the rec. with a glass plate, leaving the water in the bottom. Save this for Exp. 14.
9. What is left? What becomes of the other products?

14. PROPERTIES OF NITROGEN AND COMPOSITION OF AIR.

Ap. : graduate.

Ch. : rec. of N, splinter, match.

1. Put a burning stick into the N, sliding along the glass plate enough to admit it. Note the effect. Try this with a glowing stick.
2. See whether the P and S on the end of a match will burn in the gas. Is it a supporter of combustion?
3. Why is there no equation for this experiment?
4. To find approximately the proportion of O, measure the water accurately by pouring it into a graduate. Then measure the total capacity of the rec. in the same way, and *compute the percentage of O* (by volume) in the air, remembering that the volume of water represents the volume of O burned. If any air has been forced out, the percentage of O will be too large.
5. State the percentage of O and of N in air, as shown by this experiment.



15. TO MAKE HYDROGEN.

Ap. : p.t., 4 rec., t.t., d.t., r.s.

Ch. : 5^g Zn., 15^{cc} HCl.

1. Prepare apparatus as for making O.
2. Into a t.t. put 5^g granulated Zn, 5^{cc} H₂O and 5^{cc} HCl.
3. Have the bearings perfectly tight, and collect the gas like O. No heat need be applied.
4. If the action ceases, add more HCl. Reaction.
5. Invariably keep the rec. of H inverted on a glass plate on removing them.
6. After doing the next two experiments, wash the Zn and return it.

16. COMBUSTION OF HYDROGEN.

Ap. : lamp, glass tube (10^{cm} long, $\frac{1}{2}$ ^{cm} diam.), glass tube (50^{cm} long, 2 or 3^{cm} diam.), t.t., H gen., rec.

Ch. : rec. H, stick.

1. Lift an inverted rec. of H, and hold it in the same position over a flame, watching the result. Reaction.
2. Insert a burning stick into an inverted rec. of H. Note the effect on the stick and on the H.
3. Make a philosopher's lamp with a H gen., drawing out a glass tube for this purpose. Before lighting it, test the purity of the H, by exploding a test-tube full in the flame. When no sharp report ensues, light the flame ; avoid pointing the tube towards any one. Reaction.
4. When it burns, lower a large glass tube (2 or 3^{cm} in diam.) over the flame.
5. Hold a *dry* bottle over the flame for some time and look for moisture on the sides.
6. Collect by up. disp. a dry t.t. of H, explode it over a flame, and look for any product.

17. EXPLOSION OF HYDROGEN.

Ap. : soda-bottle, p.t., t.t., d.t., r.s., lamp.

Ch. : 2^s Zn, 5^{cc} HCl.

1. Fill a soda-bottle with water, invert it in a p.t., and fill it not over one-fifth full of H.
2. Lift the bottle, inverted, to let the water run out and air take its place.
3. Cover the mouth of the bottle with the hand, and shake well, so as to mix the H and the air.
4. Now bring its mouth to a flame.

18. TO MAKE CHARCOAL.

Ap. : lamp, r.s., small Hessian crucible, sand, e.d.

Ch. : pieces of wood about 2^{cm} long or square.

1. Put 2 or 3 small and thin pieces of wood into a small Hessian crucible, and cover them with sand.
2. Apply a strong heat for half an hour, or until gases cease to come off, then let it cool; pour off the sand (save it), and examine the wood. Notice any gases rising during the experiment. Explain.
3. Hold a piece of the charcoal in a Bunsen flame. See whether it burns with flame or only glows.
4. Hold an e.d. in the flame of a Bunsen burner, having the basal orifices closed. As gas consists mainly of compounds of H and C, explain the effect.
5. Open the orifices, and try to burn off some of the deposited C.

19. DISINFECTING ACTION OF CHARCOAL.

Ap. : t.t., 2 rec., funnel, filter paper.

Ch. : 2^g FeS, 5^{cc} HCl, 5^g charcoal.

1. Prepare a sol. of H_2S (Exp. 72) in a rec. with 20^{cc} H_2O . Notice the odor.
2. Put into the rec. 5^g powdered charcoal, and shake the mixture well.
3. Pour the whole on a filter, collect the filtrate in a clean rec., and see whether any odor remains. If so, use more coal and filter again.

20. DECOLORIZING ACTION OF CHARCOAL.

Ap. : t.t., 2 rec., funnel, filter paper.

Ch. : 5^g bone-black, 20^{cc} cochineal sol.

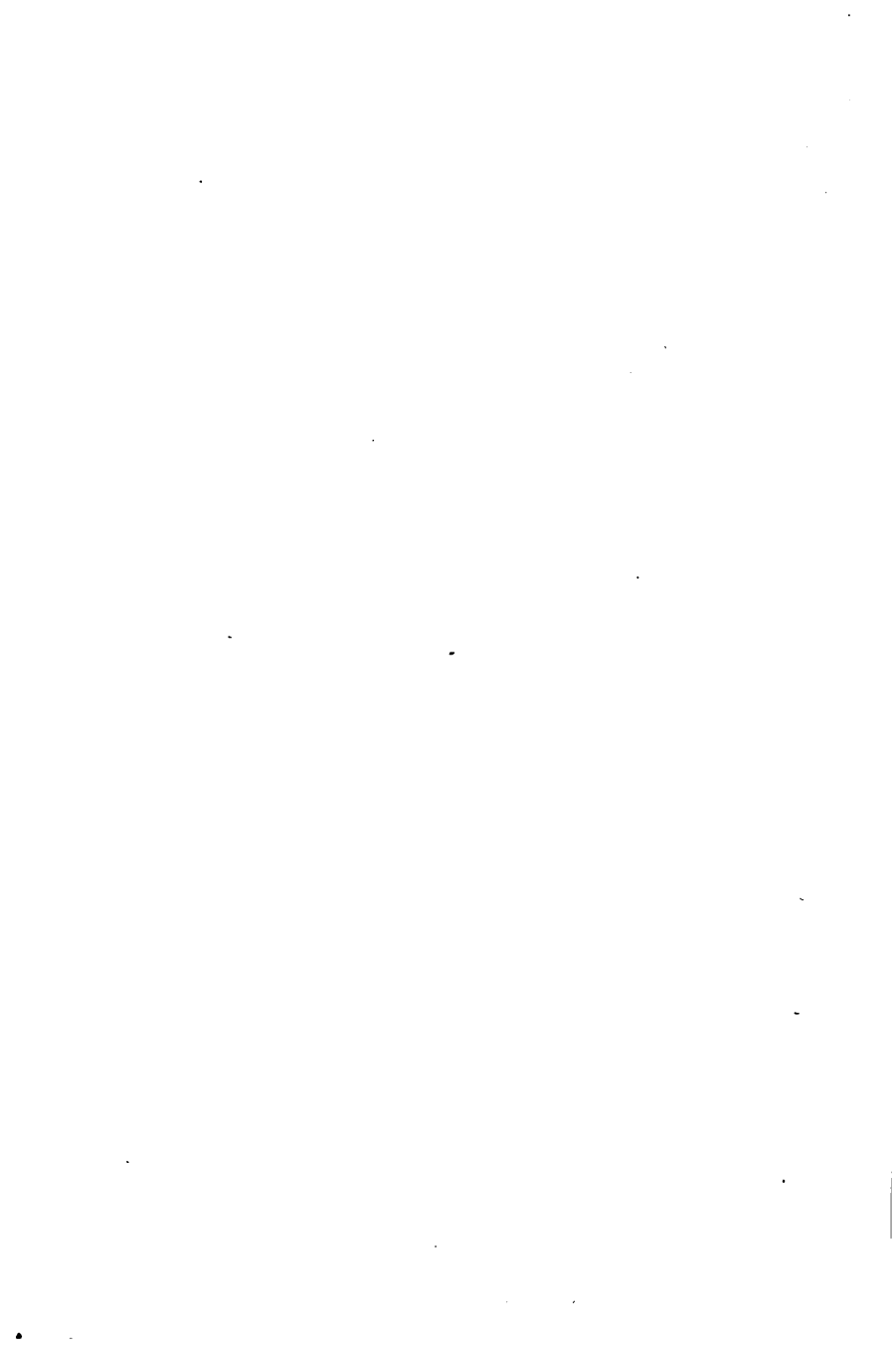
1. Put into a t.t. 5 or 10^g of bone-black, and add 10 or 20^{cc} of cochineal sol.
2. Shake well, then filter into a clean t.t., and notice the color of the liquid. If not *perfectly colorless*, pour it again on the same filter, using more C if necessary.
3. Try in the same way a sol. of $K_2Cr_2O_7$.
4. As cochineal is an animal coloring-matter, and $K_2Cr_2O_7$ is mineral, state any inference.

21. CONDENSING ACTION OF CHARCOAL.

Ap. : paper.

Ch. : 3^g bone-black, P (half the size of a pea).

1. Dry a piece of P, and put it on paper 3 or 4 folds in thickness.
2. Cover it with 3^g of powdered bone-black, and leave it in a warm place till combustion ensues.
Explain and give equation
3. Finally burn all the P.

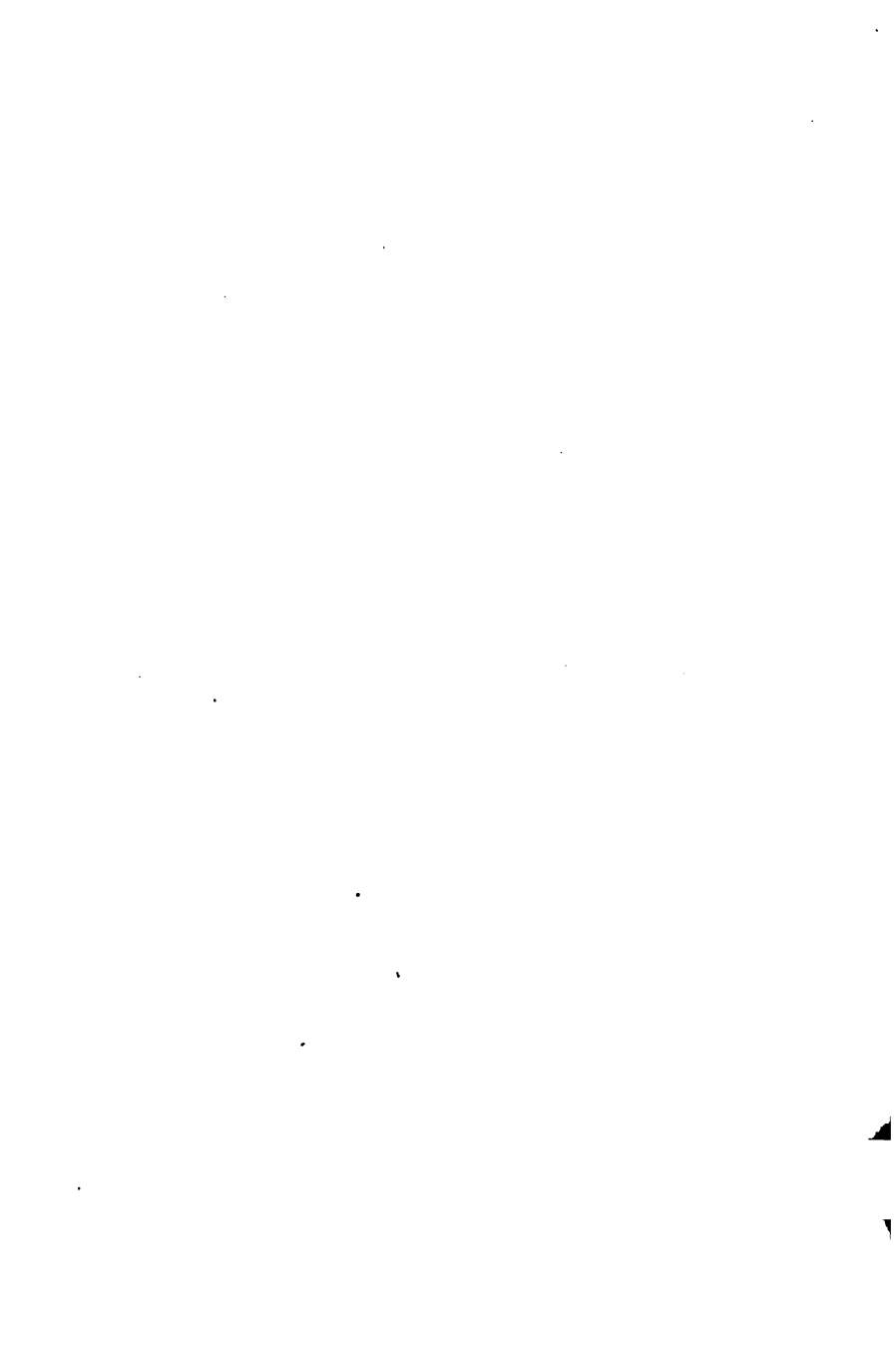


22. REDUCING ACTION OF CARBON.

Ap. : lamp, i.t., e.d.

Ch. : 5^g CuO, $\frac{1}{2}$ ^g charcoal (powdered), 3^{cc} HNO₃.

1. Mix on paper and put into a prepared i.t. (10^{cm} long, $\frac{1}{2}$ ^{cm} diam.), 10 pts. CuO to 1 pt. C, powdered charcoal, by weight 5^g in all. The tube should not be over $\frac{1}{3}$ full.
2. Heat to redness for 5 or 10 minutes.
3. Remove the contents to a paper and look for metallic Cu. $2\text{CuO} + \text{C} = ?$ $\text{CuO} + \text{C} = ?$
4. Test it by putting some into an e.d. and adding 2 or 3^{cc} HNO₃. Observe the color of the fumes and of the liquid. $3\text{Cu} + 8\text{HNO}_3 = 3\text{Cu}(\text{NO}_3)_2 + 4\text{H}_2\text{O} + 2\text{NO}$.



23. SOLUTION AND DEPOSITION OF SILVER

App.: e. l., lamp, r. s., plate.

Ch.: a zinc, a cent or a Cu wire, 5% HNO_3 .

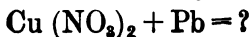
1. Put a ten-cent Ag coin or other piece of Ag into an e. l. and pour over it from a test a mixture of 5% HNO_3 and 1% H_2O .
2. When all or nearly all the Ag dissolves, then remove the lamp and take out any Ag that is left. $3 \text{ Ag} + 4 \text{ HNO}_3 = ?$ See Exp. 22.
3. Then add 1% H_2O and at once put into it a one-cent coin or a Cu wire.
4. Leave this till white deposit appears, then pour off the liquid, wash the deposit thoroughly, and remove it from the coin. $2 \text{ AgNO}_3 + \text{Cu} = ?$
5. Examine to see what the metal is, and save it.

24. SOLUTION AND DEPOSITION OF COPPER.

Ap. : e.d., r.s., lamp, plate.

Ch. : a cent or 2^r Cu, a strip of Pb, 5^{cc} HNO₃.

1. Dissolve a Cu cent or some Cu turnings in a mixture of 5^{cc} HNO₃ + 10^{cc} H₂O. Warm till the metal has nearly dissolved; then cool, remove the remainder (as in Exp. 23), add 10^{cc} H₂O, and put in a piece of Pb about the same size as the Cu used.
2. Examine the deposit, and explain fully.





25. SOLUTION AND DEPOSITION OF LEAD.

Ap. : e.d., r.s., lamp, plate.

Ch. : a piece of Pb, a piece of Zn, 5% HNO_3 .

1. Do this experiment like the two previous, dissolving a piece of Pb, not larger than a cent in 5% HNO_3 and 10% H_2O ; warm till the Pb has nearly dissolved, cool, remove any extra Pb, add 10% water and a piece of Zn the size of the Pb used.
2. Examine the deposit and identify it. $3 \text{ Pb} + 8 \text{ HNO}_3 = ?$ $\text{Pb} (\text{NO}_3)_2 + \text{Zn} = ?$
3. State what is shown by Exps. 23, 24, 25 of the electro-positive and electro-negative relation of Ag, Cu, Pb, and Zn.

26. WHAT ACIDS ARE.

Ap. : e.d., stirring rod.

Ch. : HCl , HNO_3 , H_2SO_4 (a few drops each), litmus paper (small strips).

1. Pour into an e.d. a few drops HCl , add 5^{cc} H_2O , stir it, and taste a drop from the st.r.
2. Dip the end of a strip of blue litmus paper into it; notice the effect.
3. Wash the e.d. well, then put in a few drops of HNO_3 and 5^{cc} H_2O and stir.
4. Notice the taste of this, and its action on blue litmus, as before.
5. Prepare and test similarly H_2SO_4 .
6. State your conclusions as to the action and the composition of acids, and frame a definition. Observe in this connection the common element in the three acids, and whether the rest of the symbol is negative or positive.



27. WHAT BASES ARE.

Ap. : e.d., st.r.

Ch. : NH_4OH , NaOH , KOH (a few drops each), HCl ,
litmus paper (strips).

1. Pour into an e.d. a few drops of NH_4OH , add 5^{cc} H_2O , stir it, and taste a drop.
2. Dip the end of a strip of *red* litmus paper into it. To redden blue litmus hold it in the *fumes* of HCl . To change red litmus to blue, hold it in the *fumes* of NH_4OH . One piece of litmus paper can thus be used repeatedly.
3. Wash the e.d. and prepare and test NaOH sol. in the same way.
4. Do the same with KOH sol.
5. State your conclusions regarding the action and the composition of bases. Observe the two common elements in the three bases, and whether the rest of the symbol is negative or positive. Give a definition.

28. ACID AND ALKALINE REACTIONS.

Ap. : beaker, st.r., e.d.

Ch. : 5^{cc} lit. sol., HCl, HNO₃, H₂SO₄, NH₄OH, KOH sol.
NaOH sol. (a few drops each).

1. Pour into a small beaker or a t.t. 5^{cc} of an aqueous solution of blue litmus.
2. Pour a few drops of HCl into an e.d., and dip a st.r. into this, then stir the lit. sol. with it, noticing any change of color. If there is no change, add another drop with the rod. This shows an acid reaction.
3. Pour a few drops of NH₄OH into a clean e.d., dip the st.r. into it, then stir the lit. sol. with it. If the color is unchanged, repeat till blue is again obtained. This shows an alkaline reaction.
4. In the same way put a drop—or more if needed—of HNO₃ from an e.d. into the same blue sol. When it is reddened, add a drop or more of NaOH sol., till it becomes blue.
5. Change it again to red with a drop of H₂SO₄, and restore the color with KOH sol.



29. WHAT SALTS ARE.

Ap. : e.d.

Ch. : sol. of NaCl , KNO_3 , $(\text{NH}_4)_2\text{SO}_4$, Na_2CO_3 , HNaCO_3 ,
(2^{cc} each), litmus.

1. Pour into a clean e.d. 1 or 2^{cc} of NaCl sol. in water, taste a drop of it, and test it with litmus.
2. Test in the same way 1 or 2^{cc} of KNO_3 sol.
3. Test similarly a sol. of $(\text{NH}_4)_2\text{SO}_4$.
4. State your conclusions as to the usual action of salts, and as to their composition.
5. Test, however, a sol. of Na_2CO_3 .
6. Test, also, a sol. of HNaCO_3 .

30. TO MAKE SODIUM CHLORIDE.

Ap. : r.s., lamp, plate, asbestos, e.d., st.r., 2 t.t., beaker.
Ch. : 5^{cc} sol. NaOH, 5^{cc} HCl, litmus.

1. Measure in a t.t. 5^{cc} NaOH sol. and pour it into an e.d.
2. Pour into a clean t.t. 4 or 5^{cc} HCl, and add some of this, a little at a time, to the NaOH sol., stirring it meantime, till the product is neutral to litmus paper. When nearly neutral, add a drop at a time with the st.r. Test with both colors. Turn the paper from one color to the other as directed in Exp. 27. Use only the end of the paper, putting it on the side of the e.d. If blue litmus paper is reddened, add NaOH sol., a drop at a time. If red litmus is turned blue, add a drop of HCl.
3. When no effect is produced on either red or blue litmus after leaving for a minute, show the sol., with both red and blue litmus in it, to the instructor, then filter and evaporate the liquid to dryness by boiling it over a plate and asbestos paper.
4. When cool, examine the residue and taste it. Reaction. What is the object of evaporation?



31. TO MAKE POTASSIUM SULPHATE.

Ap. : same as in last experiment.

Ch. : 5% KOH sol., 5% H_2SO_4 , litmus.

1. Into an e.d. put 5% KOH sol.
2. Neutralize it with H_2SO_4 from a t.t., as in the previous experiment.
3. When it is absolutely neutral, evaporate the water.
4. Taste the product. Give the equation.

32. TO MAKE AMMONIUM NITRATE.

Ap. : same as in previous experiment.

Ch. : 5% NH_4OH , 5% HNO_3 , litmus.

1. Put into an e.d. 5% NH_4OH .
2. Neutralize this with HNO_3 from a t.t. or beaker, as in the previous experiment.
3. Evaporate till white fumes begin to appear.
4. Cool, and taste the residue. Reaction.
5. After writing up this experiment, write reactions for the union of: (1) NaOH and HNO_3 , (2) NaOH and H_2SO_4 , (3) KOH and HNO_3 , (4) KOH and HCl , (5) NH_4OH and HCl , (6) NH_4OH and H_2SO_4 . Use a separate line for each. State a method of preparing salts.

33. TO MAKE CHLORHYDRIC ACID.

Two pupils may work together.

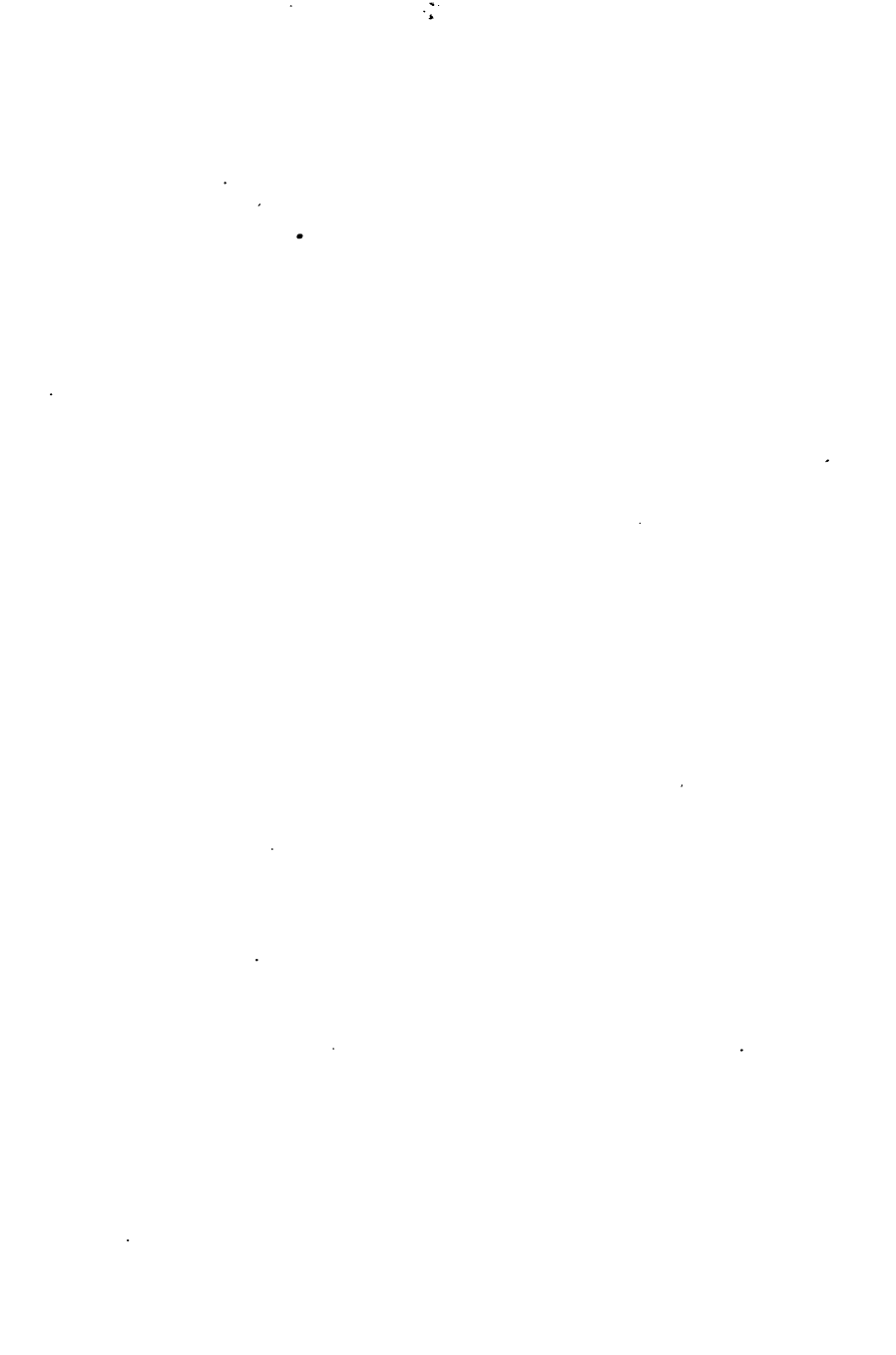
[Read RULE 11.]

Ap. : r.s., lamp, plate, asbestos, flask, d.t., rec. (for Wolff bottles).

Ch. : 10% NaCl, 20% H_2SO_4 , 2% NH_4OH .

1. Into a flask put 10% NaCl and 20% H_2SO_4 . Be sure to have enough acid, or the flask will crack.
2. Fill two or more rec. one-quarter full of water.
3. Connect the apparatus as in the model, observing how the tubes extend, and having one ring above the flask to hold it.
4. Heat slowly 15 minutes over asbestos. Do not let the frothing extend to the neck of the flask. Reactions. Look for any current in the liquid of the rec. On detaching the apparatus, pass a little of the gas over some NH_4OH in an e.d. Notice the fumes, and write the equation.
5. Let the flask stand till cool, then clean it with water.

[If the gas is accidentally breathed, inhale NH_3 .]



34. TESTS FOR CHLORHYDRIC ACID.

Ap. : t.t., e.d.

Ch. : lit., rec. HCl, bit of Zn, 2^{cc} Pb(NO₃)₂ sol., 2^{cc} AgNO₃ sol., 2^{cc} HgNO₃ sol.

1. Test the liquid in each rec. with lit., and taste a drop.
2. Pour 10^{cc} from the *first rec.* into a t.t., and add a piece of Zn. Reaction. Ignite the escaping gas.
3. Put into a t.t. 2^{cc} AgNO₃ sol., and add 2^{cc} of the liquid from the first rec. Reaction. What is the ppt.?
4. Put into a t.t. 2^{cc} Pb(NO₃)₂ sol., and add 2^{cc} of the liquid from the first rec. Reaction. Name the ppt.
5. Put into a t.t. 2^{cc} HgNO₃ sol., and add 2^{cc} of the liquid from the first rec. Name the ppt. Reaction.

35. FLUORHYDRIC ACID AND ETCHING.

Ap. : lead tray (5 or 6^{cm} square 1^{cm} deep), r.s., lamp, plate, glass.

Ch. : 2^s CaF₂, 4^{cc} H₂SO₄, piece of beeswax.

1. Cover thinly with beeswax one side of a small piece of glass. Spread the wax evenly over the surface by warming the other side of the glass.
2. With a sharp metallic point mark some design through the wax when it is hard.
3. Put into a lead tray 2^s powdered CaF₂, cover it with H₂SO₄, and mix.
4. Lay the glass, wax side down, over the tray, and put this *high above a small flame*, so as to *warm* the contents and not melt the wax.
5. After 5 or 10 minutes remove the lamp, and leave the tray and glass in a warm place for at least half an hour; two hours would be better. Avoid inhaling the gas. $\text{CaF}_2 + \text{H}_2\text{SO}_4 = ?$
6. Remove the wax, clean the glass with a cloth wet with benzine or naphtha, and look for the design. $4 \text{HF} + \text{SiO}_2 = ?$

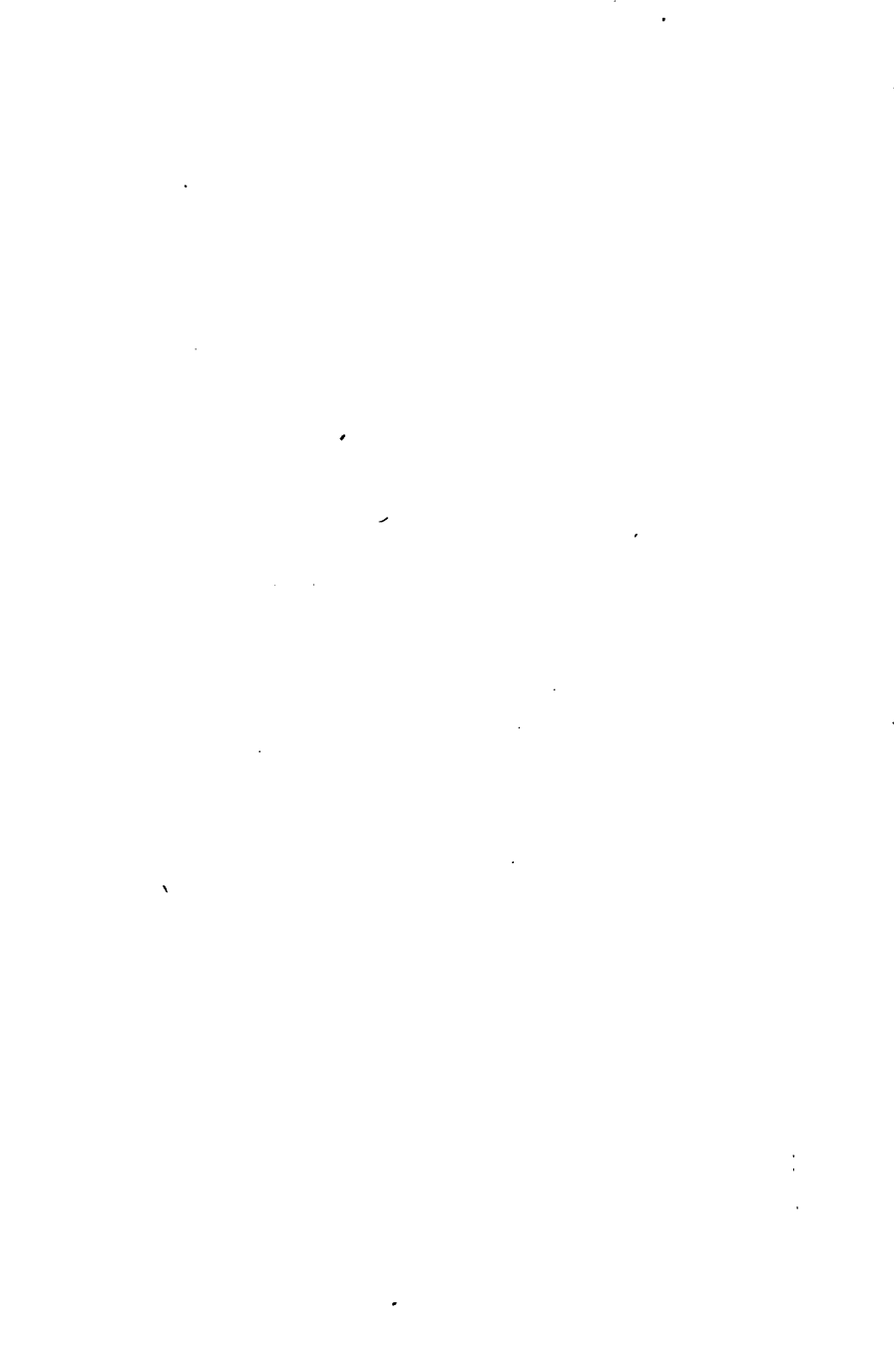


36. TO MAKE NITRIC ACID.

Ap. : r.s., lamp, plate, asbestos, flask, d.t., t.t., rec.

Ch. : 5^g NaNO₃ (or KNO₃), 10^{cc} H₂SO₄.

1. Put into a flask or large t.t. 5^g NaNO₃ (or KNO₃) and 10^{cc} H₂SO₄.
 2. Attach a d.t. and fit a cork tightly.
 3. Put the other end of the d.t. into a t.t., and sink this to the bottom of a rec. of water.
 4. Heat the flask on a r.s. over asbestos, and collect 4 or 5^{cc} of the liquid. Take care that none of the salt passes over. If a t.t. is used, put the flame against the upper part of the liquid. Avoid having the liquid draw back by removing the t.t. as soon as the heat is taken away.
 5. Note the color of the acid, and account for it.
- Equations.



37. TESTS FOR NITRIC ACID.

Ap. : t.t., e.d.

Ch. : lit., a bit of white silk (or quill), $\frac{1}{2}$ Cu turnings, 1^{cc} cochineal sol., 1^g charcoal, 5^{cc} HNO₃.

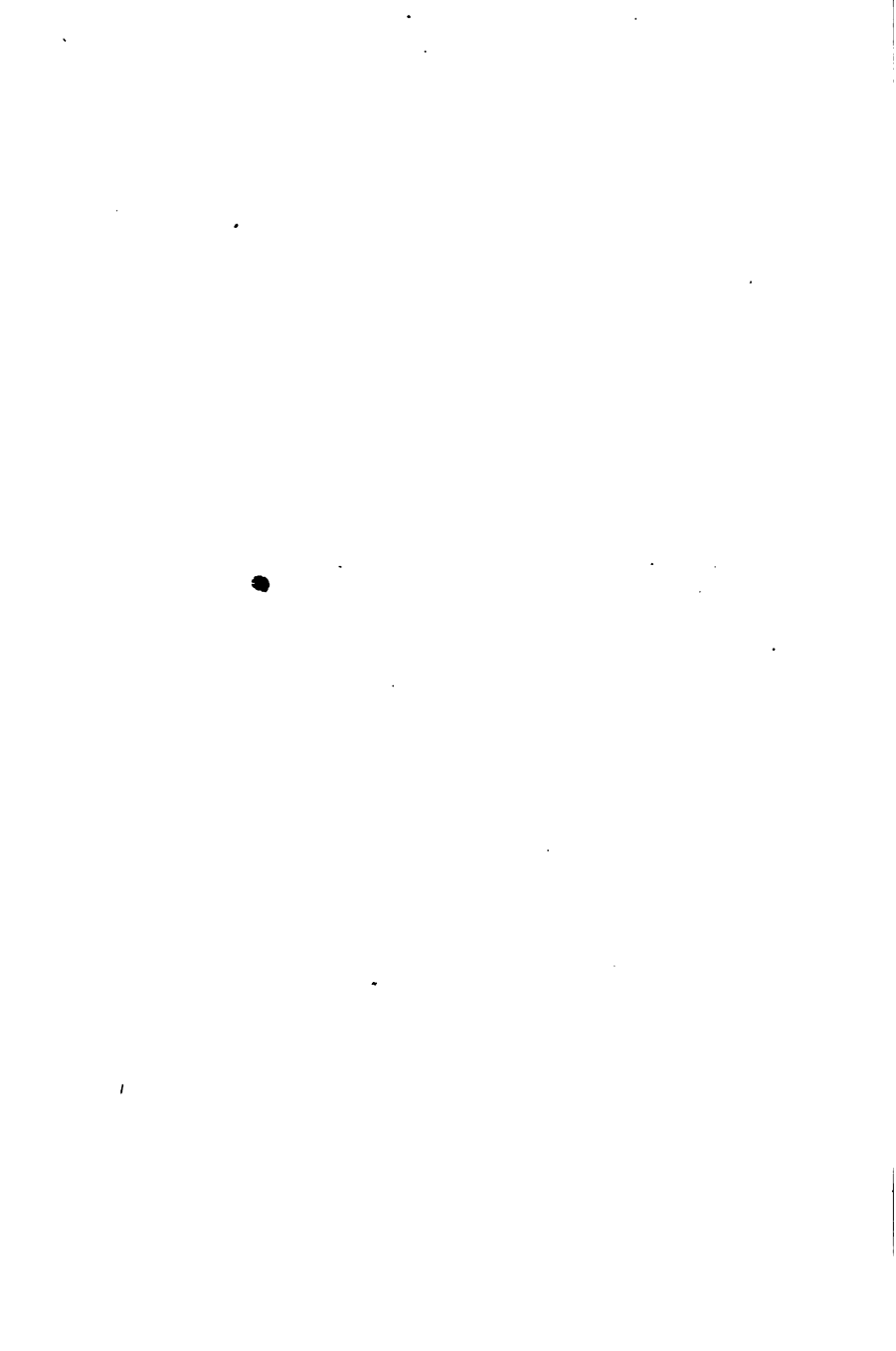
1. Test with lit. the liquid prepared in the last experiment.
 2. Put a drop on the finger with a st.r., and wash it off at once. Note any color.
 3. Dip a quill or piece of white silk into it for an instant, then wash it, noticing the color.
 4. Add a little to a few bits of Cu turnings in an e.d. Reaction. See Exp. 22.
 5. To 1^{cc} indigo solution add 1^{cc} HNO₃. Result.
 6. Heat in an e.d. 1^g fine charcoal, and then add 1^{cc} HNO₃.
- 2, 3, 4, 6 are characteristic tests.

38. NITRO-HYDROCHLORIC ACID.

Ap. : 2 t.t.

Ch. : 2^{cem} Au leaf, 6^{cc} HCl, 2^{cc} HNO₃.

1. Put into each of 2 t.t. 1^{cem} of gold leaf.
2. To one add 6^{cc} HCl, to the other 2^{cc} HNO₃. If the gold does not disappear from either, boil each for an instant.
3. Pour the two acids together, and observe.
$$3 \text{ HCl} + \text{HNO}_3 = \text{NOCl} + 2 \text{ H}_2\text{O} + ? \quad \text{Au} + 3 \text{ Cl} = ?$$



39. SULPHUROUS ACID.

Ap. : lamp, 2 t.t., d.t.

Ch. : lit., 3^s Cu, 4^{cc} H₂SO₄.

1. To 2 or 3^s Cu turnings in a t.t. add 3 or 4^{cc} H₂SO₄.
2. Attach a d.t. that leads into an open t.t., in which are 5 or 10^{cc} H₂O, and attach to a r.s. Heat the t.t. containing the reagents and let the gas bubble, for 2 or 3 minutes, through the water. Cautiously take the odor.
3. Reactions for the liberation of SO₂, and for its combination with H₂O. •
4. What is another mode of making H₂SO₃?



40. TO MAKE SULPHURIC ACID.

Two pupils may work together.

Ap. : 1 rec., 3 t.t., 3 d.t., 2 lamps, r.s.

Ch. : 10^g Cu turnings, 5^{cc} H₂SO₄, 5^{cc} HNO₃.

1. Fit a rec. or a large t.t. with a cork which has 4 perforations, 3 of which are to be connected by a d.t. to 3 other t.t., the fourth to be left open. Fit the stopper loosely to the rec.
2. Into one t.t. put 10^{cc} H₂O; into another 5^g Cu and 5^{cc} H₂SO₄; into the third 5^g Cu, 5^{cc} H₂O, 5^{cc} HNO₃.
3. Connect each t.t. with the rec. by a d.t. Put the rec. on an iron plate on the r.s., and heat the tubes containing H₂O and H₂SO₄, also the other if necessary. Collect a little liquid in the rec. Avoid forcing over any liquid. If any goes over from the H₂SO₄ or the HNO₃ tube, clean out the rec. and begin again.
4. Give the equation for the reaction in each t.t. and in the rec. Make a diagram of the ap.

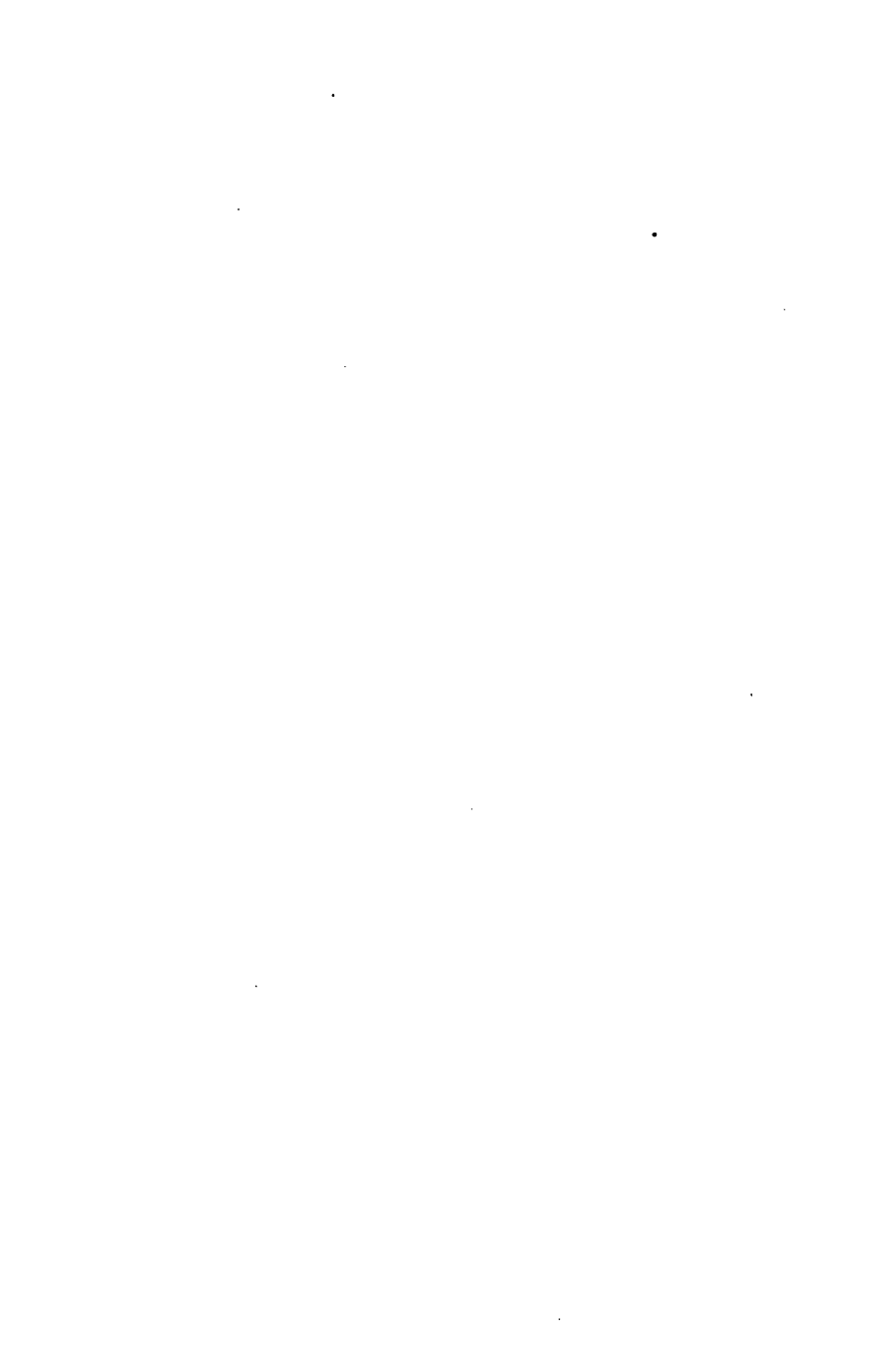


41. TESTS FOR SULPHURIC ACID.

Ap. : t.t.

Ch. : lit., BaCl_2 sol. (few drops), H_2SO_4 (from previous experiment, also from reagent bottle), 2^{cc} sugar sol., splinter, starch (fragment).

1. Test with lit. the liquid generated in the previous experiment.
- 2. To some of the liquid poured into a t.t. add a few drops of clear BaCl_2 sol., and look for a ppt. This is a test for H_2SO_4 , and for the soluble sulphates. Give the reaction and name the product.
3. Put one drop H_2SO_4 (from reagent bottle) into a clean t.t., add 10^{cc} H_2O , shake, add one drop BaCl_2 sol., and look for a ppt.
4. Put one drop of strong H_2SO_4 , and one from that just made, on writing-paper, and evaporate them high over a flame, so as not to burn the paper. When dry, examine.
5. Put 2^{cc} of strong H_2SO_4 into a t.t. and dip into it a splinter. Wood and paper are mostly cellulose, $\text{C}_{18}(\text{H}_2\text{O})_{15}$. Explain the charring.
6. To 2^{cc} sugar sol., $\text{C}_{12}(\text{H}_2\text{O})_{11}$, add 2^{cc} H_2SO_4 , and explain.
7. Cover a fragment of starch, $\text{C}_6(\text{H}_2\text{O})_5$, with H_2SO_4 in a t.t.; boil till it begins to blacken. Explain.



42. ACTION OF SULPHURIC ACID ON WATER.

Ap. : small t.t., also large one, e.d., graduate, 2 rec.

Ch. : 2^{cc} NH₄OH, 25^{cc} H₂SO₄.

1. Into a very small t.t. put 2^{cc} NH₄OH.
2. Pour into an e.d. or a beaker 5^{cc} H₂O, and into this pour slowly 15^{cc} H₂SO₄. Use the small t.t. containing the NH₄OH for a st.r., while mixing them, and look for any ebullition. Observe, with a chemical thermometer, the temperature of the water before mixing, then of the mixture. Notice the heat of the e.d. and of the t.t.
3. Measure in a graduate exactly 10^{cc} H₂SO₄ and pour it into a rec. or beaker. Set this aside till the next lab. hour, putting into another open rec. near by, twice as much water or more. Mark the one having H₂SO₄.
4. At the next hour (next week) measure accurately the volume of H₂SO₄. Save the acid.



43. TO MAKE AMMONIUM HYDRATE.

[Read RULE 11.]

In this experiment two pupils may work together.

Ap. : mortar, flask, 2 (or more) rec. (for Wolff bottles),
d.t., e.d., lamp, r.s., plate, and asbestos.

Ch. : 10^g NH₄Cl, 10^g Ca(OH)₂, 2^{cc} HCl, lit., 5^{cc} FeSO₄ sol.

1. Powder and put into a flask 10^g NH₄Cl and 10^g freshly slaked Ca(OH)₂.
2. Add 25^{cc} H₂O, and connect with Wolff bottles containing water, as in making HCl. Have the tubes as in the model.
3. Heat 10 minutes, using a plate and asbestos paper. Reaction.
4. Disconnect the flask, put 2^{cc} HCl into an e.d., and pass the gas over it from the gen. Observe the fumes, and give the reaction for them. This is the test for ammonia. Let the flask cool as it stands, and test the liquid in the rec. with red lit.
5. Put 5^{cc} FeSO₄ sol. into a t.t., and pour in 2 or 3^{cc} of the prepared NH₄OH. Note effect and color, and write reaction. Name the ppt.



44. AMMONIA.

Ap. : mortar, lamp, t.t.

Ch. : 5^g NH_4NO_3 , 5^g $\text{Ca}(\text{OH})_2$, lit.

1. Pulverize 5^g NH_4NO_3 in a clean mortar.
2. Mix with it 5^g fine $\text{Ca}(\text{OH})_2$.
3. Put them into a t.t., and warm it. Equation.
4. Test the gas by holding lit. at the open end of the tube while heating it. Test it also with HCl . Equation. Notice the odor



45. AMMONIA.

Ap. : lamp, t.t.

Ch. : 5% NH_4Cl (or NH_4NO_3), 5% NaOH (or KOH) sol., lit.

1. Put into a t.t. 5% NH_4Cl (or NH_4NO_3), and add 5% NaOH (or KOH) sol.
2. Warm it and apply the same tests as before.
Equation.

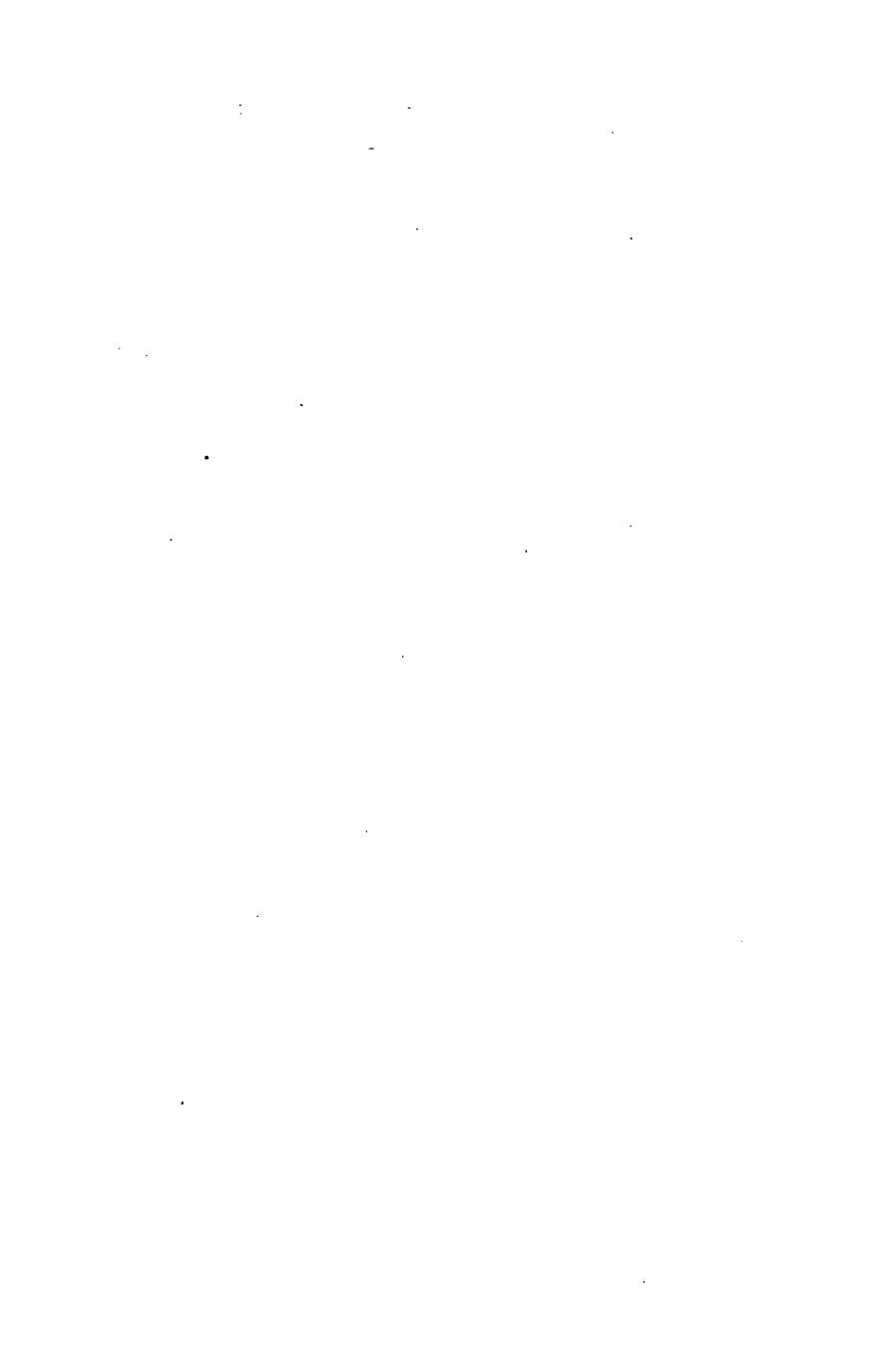


46. TO MAKE POTASSIUM HYDRATE.

Ap. : rec., paper.

Ch. : K (half size of pea), lit.

1. Put 20^{cc} H₂O into a clean rec.
2. Take from the naphtha in which it is kept a piece of metallic K, using forceps and e.d.; drop it into the rec., and at once cover this loosely with paper. Note the color of the flame and the activity of the combustion.
3. When action ceases, test the liquid with red litmus, and draw an inference as to the class of compounds to which it belongs.
4. What is the color, and what the lustre of freshly cut K; also its sp. gr. as compared with water?
5. Write equations for (1) the union of K and H₂O, (2) the combustion of H, (3) the combustion of K.



47. TO MAKE SODIUM HYDRATE.

Ap. : rec., paper.

Ch. : Na (half size of pea), lit.

1. Put into a clean rec. $20^{\circ}\text{H}_2\text{O}$.
2. Drop into this a piece of metallic Na, and cover the rec. as in Exp. 46. Compare the color and the lustre of freshly cut Na, and its chemical activity with those of K. Equation.
3. Test the liquid with red lit., and draw inference.
4. Heat $10^{\circ}\text{H}_2\text{O}$ in a t.t. and pour it into a rec. Drop into the hot water a piece of Na, and cover the rec. with paper. Do not watch it at too close a range. Why was it more active than before? Write three equations for this.

48. TO MAKE SODIUM HYDRATE.

Ap. : e.d., lamp, r.s., plate, lit.

Ch. : 5^g Na_2CO_3 , 2^g $\text{Ca}(\text{OH})_2$.

1. Dissolve 5^g crystals of Na_2CO_3 in 20^{cc} H_2O , and heat just below boiling in an e.d.
2. Then add a mixture of 2^g $\text{Ca}(\text{OH})_2$ in 8^{cc} H_2O .
3. Boil five minutes. Cool, and pour off the liquid or filter it. Test with lit. $\text{Na}_2\text{CO}_3 + \text{Ca}(\text{OH})_2 = ?$
4. What is the insoluble residue? By evap. the NaOH can be obtained as a solid.
5. Write equation for making KOH similarly.

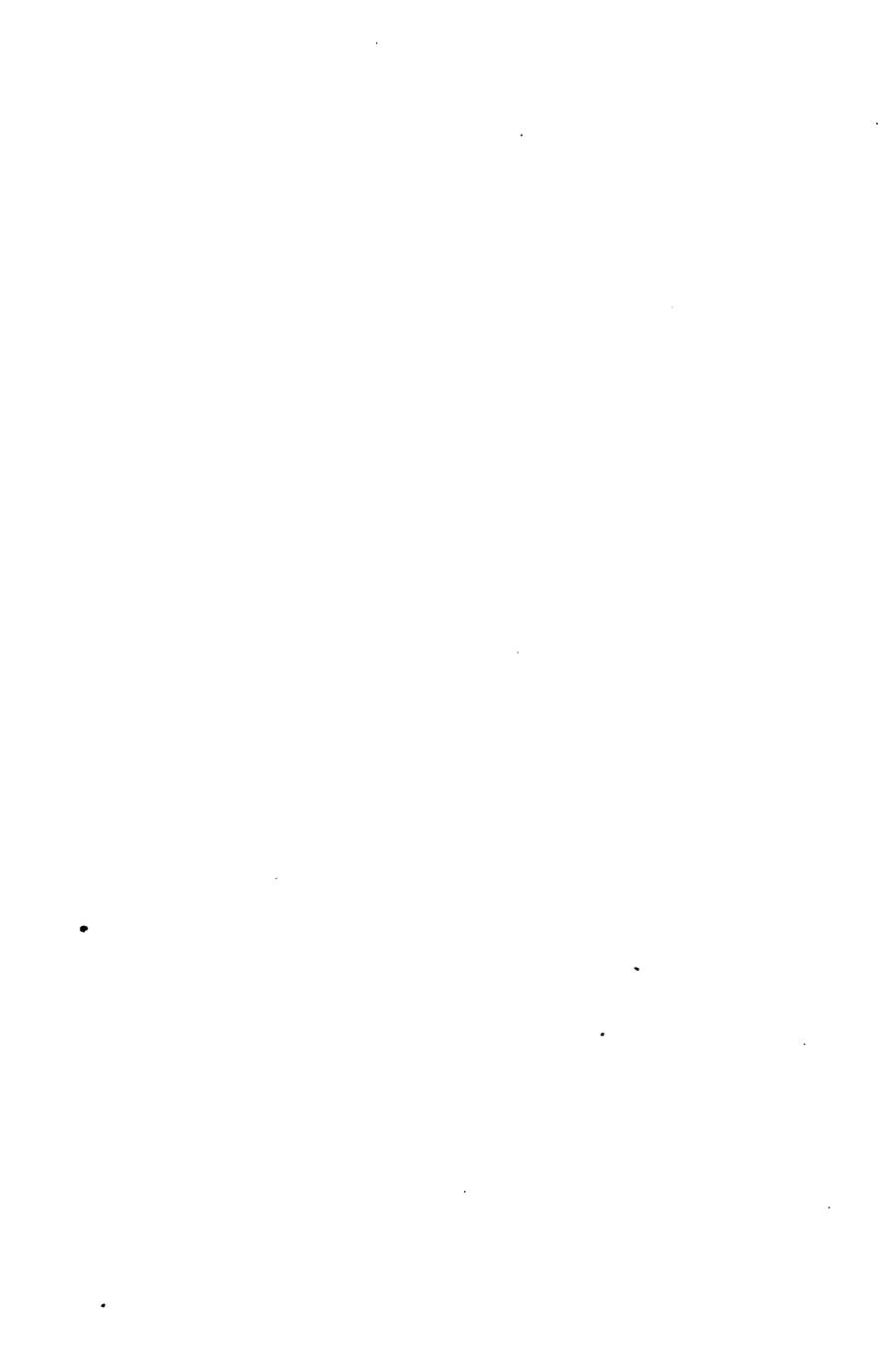
49. TO MAKE NITROGEN PROTOXIDE.

In this experiment two pupils may work together.

Ap. : r.s., lamp, flask, 2 d.t., 3 rec., large t.t., p.t.

Ch. : 10^g NH₄NO₃, lit.

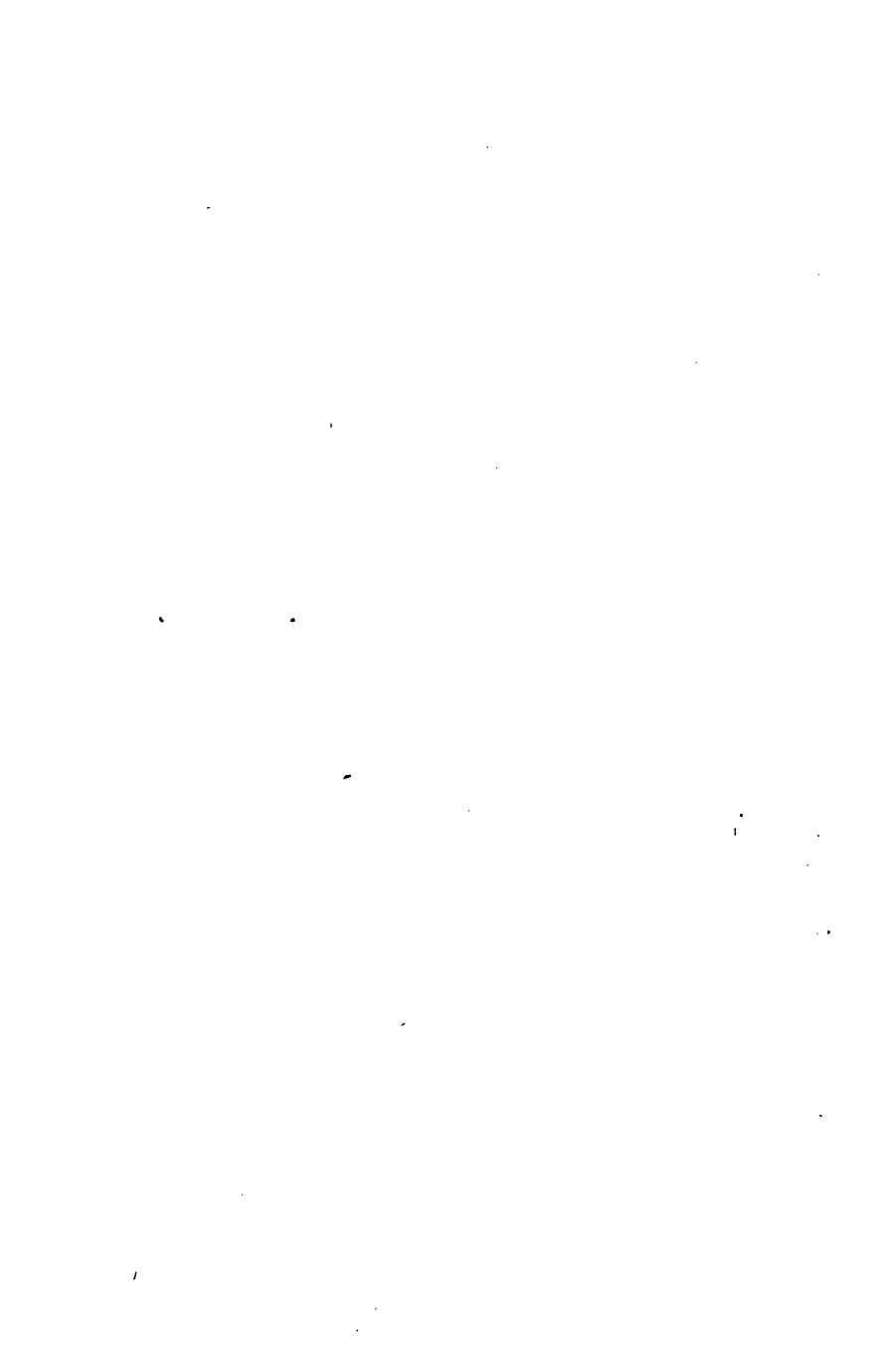
1. Put into a flask (of 200^{cc}) 10^g NH₄NO₃.
2. Connect the flask with a large t.t. or rec., resting in a rec. of H₂O, and from this t.t. have a d.t. leading to a p.t., so as to collect the gas over water. Have the bearings tight.
3. Heat not too rapidly. Obtain 2 rec. of gas, then remove the lamp and take the d.t. from the water. Cool the flask on the r.s. Equation.
4. Taste *a drop* of the liquid in the large t.t., and test it with red and blue lit. Some NH₄NO₃ will probably have been driven over.



50. COMBUSTION IN NITROGEN PROTOXIDE.

Ch. : rec. N_2O (2 or more), stick, S, P (small bit of each).

1. Try a burning stick in a rec. of N_2O , also a red-hot one.
2. Try the combustibility of S or of P, or both, in N_2O . Have the S burning briskly.

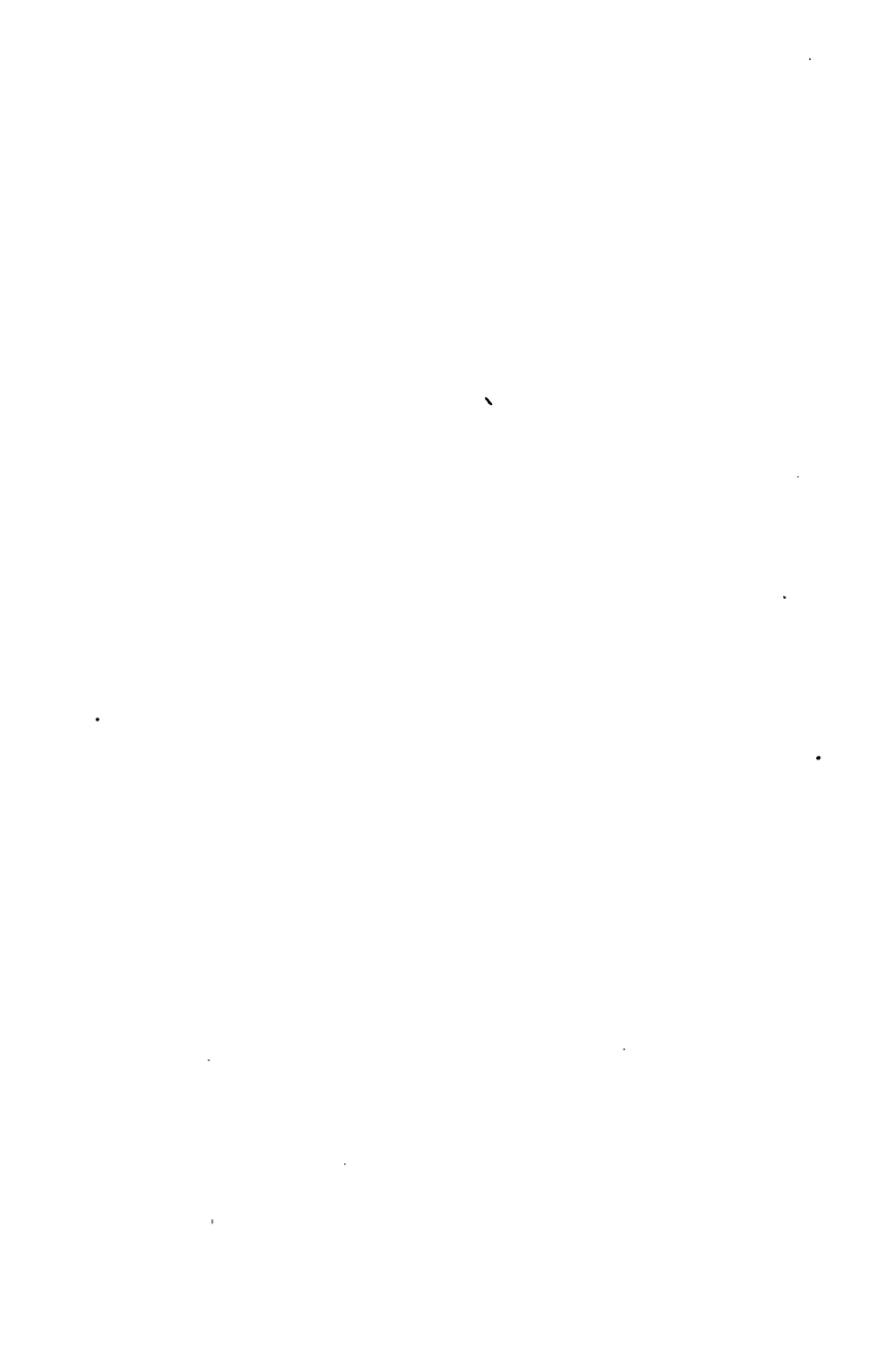


51. TO MAKE NITROGEN DIOXIDE.

Ap. : r.s., t.t., d.t., p.t., 2 rec.

Ch. : 5^g Cu turnings (fine), 10^{cc} HNO₃.

1. Put into a t.t. 5^g Cu turnings, 5^{cc} H₂O, 5^{cc} HNO₃.
2. Arrange the apparatus as in the H experiment, and collect the gas (2 rec.) over water.
3. If necessary, add more of reagents (Cu, H₂O, HNO₃), and moderate heat may be applied.
Equation. [Exp. 22.]



52. COMBUSTION IN NITROGEN DIOXIDE.

Ap. : def. sp.

Ch. : splinter, S, P (same size as usual).

1. Try a burning stick in NO. Also, with the same rec., try burning S in a def. sp. or on a wire.
2. Try P when *well burning*. Admit as little air as possible. If it burns, give the equation.
3. Finally burn all the P as usual.



53. NITROGEN TETROXIDE.

Ap. : t.t., lamp.

Ch. : rec. NO, 1^g Pb(NO₃)₂, 1^g starch, 1^{cc} HNO₃, splinter.

1. Lift a rec. of NO from the p.t. Reaction.
2. Heat 1^g of powdered Pb(NO₃)₂ in a t.t. $\text{Pb(NO}_3)_2 = \text{PbO} + 2 \text{NO}_2 + ?$
3. To 1^g of starch in a t.t. add 1^{cc} HNO₃, and heat a moment.
4. Put a burning stick into the gas. Is the latter a supporter of combustion ?

54. CARBON DIOXIDE.

Ap. : 2 t.t., d.t., rec., lamp, glass tube.

Ch. : 5^s CaCO₃, 10^{cc} HCl, 5^{cc} Ca(OH)₂ sol., candle.

1. Put 5^s CaCO₃ (marble in lumps) or Na₂CO₃ into a t.t., or a rec.; add 5^{cc} H₂O, and 5^{cc} HCl. Add more of the reagents as needed. Enough must be used to produce vigorous action. Equation.
2. Test the gas with a burning stick.
3. Attach a d.t. and collect one rec. of gas by down. disp., covering the rec. loosely with paper.
4. Pour a rec. of the gas down over a burning stick or candle, and note result.
5. Let the gas bubble from a d.t. into 5^{cc} Ca(OH)₂ sol. in another t.t. Look for a ppt. Equation. Let the action continue till the liquid clears. There is now excess of CO₂. $\text{CO}_2 + \text{H}_2\text{O} = ?$
6. When the sol. is clear, boil for a minute, and notice the reappearance of the ppt. $\text{H}_2\text{CO}_3 - \text{CO}_2 = ?$
7. Explain the phenomena.
8. Take 2^{cc} Ca(OH)₂ sol. in a clean t.t., and blow into it through a glass tube. What does the result show?
9. Put a little Ca(OH)₂ sol. in an e.d., and look for a scum after a few minutes. Explain.

55. STRUCTURE OF FLAME.

Ap. : lamp.

Ch. : candle.

1. Examine the structure of a Bunsen burner (unscrew the top), make a drawing to show the orifices, and state what use each subserves. Light the gas at the base for a minute.
2. Replace the top, and light the gas at the top of the burner.
3. Hold the flame in front of a dark object, examine the parts, make a drawing, give a brief description, and state the color of each part.
4. Put the flame in direct sunlight, and study the parts from its shadow, to confirm your results.
5. Make a careful examination of the parts and colors of a candle flame, and make a drawing to show them. Move it slightly in the air to show the outer flame. This is best seen in a dark room.

56. COMBUSTION OF FLAME.

Ap. : lamp, small d.t., Pt wire.

Ch. : stick, paper, wire gauze.

1. Light the gas of a Bunsen burner.
2. Put a stick across the base of the flame for an instant, and notice what parts are burned. Make a sketch.
3. Hold a stick just above the inner blue cone of the flame.
4. Press quickly down on the flame with a paper, remove before it burns, and notice the shape of the charred part. Sketch. Press down on the flame with a fine wire gauze, and observe by the glowing of the wire where the heat is most intense.
5. Test the heat of the *inner cone* with the end of a Pt wire. Notice that it glows when near the top, but not elsewhere in this cone.
6. Put one end of a small d.t. into the inner blue cone, and try to light the gas at the other end.
7. From the above state what takes place in each of the two chief parts of the flame.



57. LIGHT OF FLAME.

Ap. : lamp, e.d.

Ch. : $\frac{1}{4}$ fine charcoal.

1. Observe the light of a Bunsen flame, and its color.
2. Sprinkle a very little charcoal dust in the flame, and note any change of light or color.
3. Close the orifices at the base of the burner, and explain the change of light.
4. Hold an e.d. in the upper part of this closed flame for a minute, and notice deposit.
5. Now open the orifices and persistently try to burn off a little of the deposit from the e.d.
6. What is the cause of light in a flame?

58. TO CONFINE FLAME.

Ap. : lamp, 2 pieces wire gauze (10^{cm} square).

1. Light the gas and hold a fine wire gauze 3 or 4^{cm} above the burner. Why does it not burn above the wire?
2. Extinguish, then relight the gas above the gauze. Result.
3. Gradually lift the wire till the gas will not burn.
4. Again light the gas above the gauze, and hold another gauze above the flame, so as to confine it above and below.
5. From this experiment define *kindling point*, and state three conditions of combustion.

59. OXIDIZING AND REDUCING FLAMES.

Ap. : charcoal, blow-pipe, lamp.

Ch. : Pb (small bit) ; $\frac{1}{2}$ s PbO.

1. Put a fragment of Pb, not larger than a pea, on a piece of charcoal, slightly hollowed out to hold it.
2. Insert the metallic tube in a Bunsen burner, and with a mouth blow-pipe blow the *oxidizing flame* strongly and steadily against the Pb for 4 or 5 minutes.
3. As you stop blowing, notice the yellow vapor that escapes from the pellet of Pb ; also, as it cools, the yellow coating of PbO on the coal. Reaction.
4. Put $\frac{1}{2}$ s PbO on a piece of charcoal. With the blow-pipe blow the *reducing flame* steadily against it for some time, or until a metallic pellet is obtained. What is it ? Equation.
5. Extinguish the fire, if the coal still glows, by a jet of water.

60. TO MAKE CHLORINE AND TO BLEACH.

Ap. : 2 rec., t.t., paper.

Ch. : 5^s MnO₂, 10^{cc} HCl, Turkey-red cloth, green leaf, printing and writing.

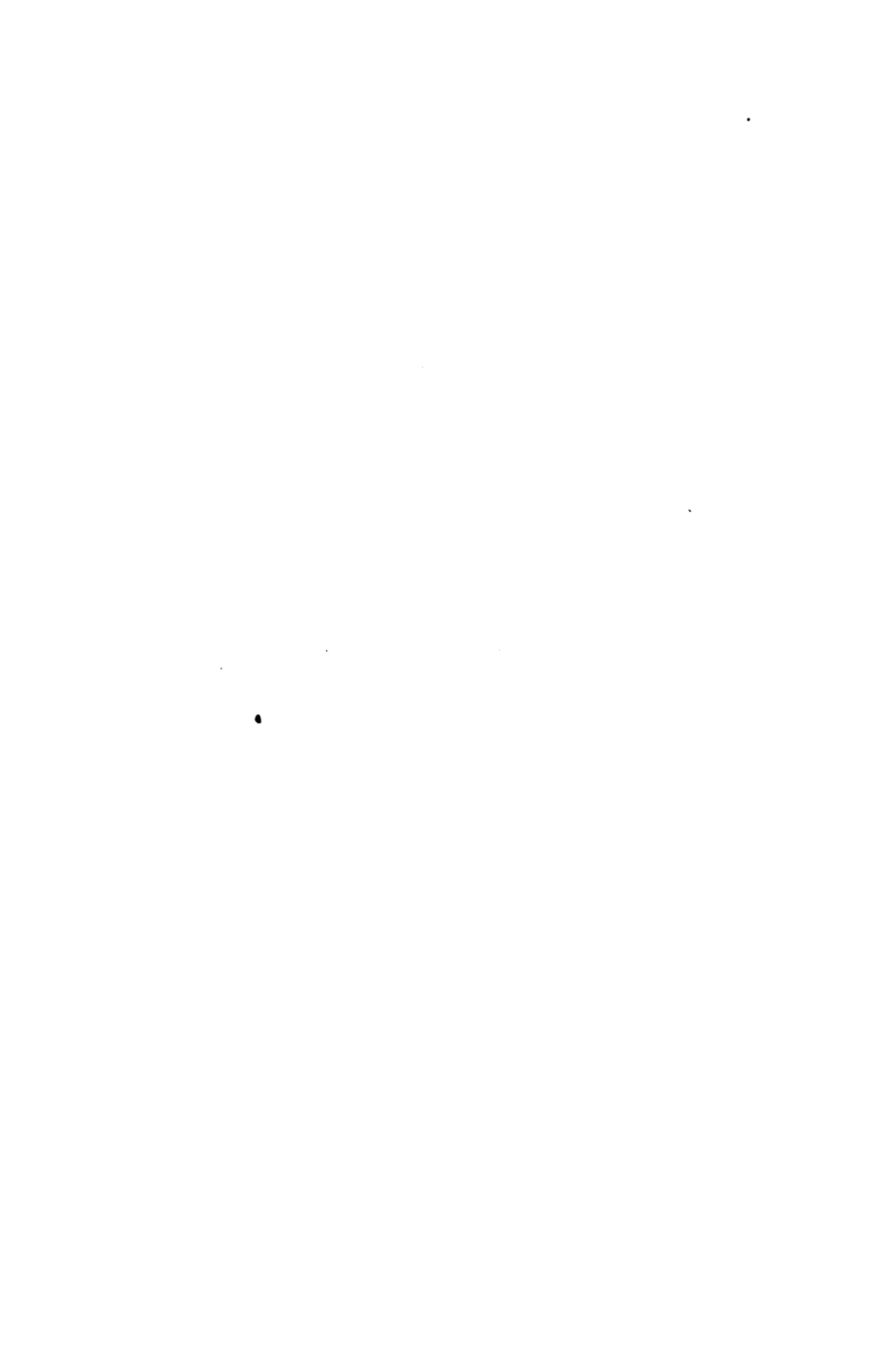
1. Suspend in a rec. a small piece of wet Turkey-red cloth, also a dry piece ; a piece of printed paper and a written one (both wet), and a leaf or colored flower.
2. Put into a t.t. 5^s MnO₂ and 10^{cc} HCl. Shake the mixture well.
3. Collect the gas by down. disp. in the rec. loosely covered with paper. Apply heat gently, and avoid inhaling the gas. Reaction.
4. Note the color of the gas, and its sp. gr. as compared with air. Observe when the rec. is filled, to avoid passing the gas into the room. If, accidentally, you breath any Cl, inhale the vapor of alcohol from a handkerchief ; or NH₃ will answer.
5. Printer's ink contains C (a mineral pigment) ; writing ink, a vegetable coloring-matter. State the action of Cl on each.
6. State the theory of the chemistry of bleaching.

61. COMBUSTION IN CHLORINE.

Ap. : e.d., paper (unglazed).

Ch. : 3 rec. Cl, a little spirits of turpentine, a bit of Sb, As, or Cu (powdered), naphtha.

1. Charge 2 or 3 rec. with Cl by down. disp.
2. Dip some unglazed paper into oil of turpentine, $C_{10}H_{16}$, in an e.d.; warm it by holding near a flame for a minute, but do not set it on fire; then thrust it into a rec. of Cl. Explain the combustion. Reaction. Clean the rec. with naphtha or petroleum.
3. Sprinkle a pinch of finely powdered Sb, As, or Cu into a rec. of Cl. Reaction.



62. CHLORINE FROM SODIUM CHLORIDE.

Ap. : r.s., lamp, 2 t.t., d.t., rec.

Ch. : 1^s NaCl, 1^s MnO₂, 3^{es} H₂SO₄.

1. Mix 1^s of fine NaCl and 1^s MnO₂, and add to them 2^{es} H₂O and 3^{es} H₂SO₄, in a t.t.
2. Pass a d.t. from this to a rec.
3. Heat, and notice the Cl gas.
4. $2 \text{ NaCl} + 3 \text{ H}_2\text{SO}_4 + \text{MnO}_2 = ?$ or
 $2 \text{ NaCl} + 2 \text{ H}_2\text{SO}_4 + \text{MnO}_2 = ?$

63. CHLORINE FROM BLEACHING-POWDER.

Ap. : small beaker (25 or 50^{cc}), large one (1000^{cc})

Ch. : 5^g bleaching-powder, 10^{cc} H₂SO₄.

1. Put into a small beaker 5^g bleaching-powder, CaCl₂ + Ca(ClO)₂; set this in a large beaker, and hang in the latter the substance to be bleached.
2. Cover the large one with pasteboard, through which passes a thistle-tube into the smaller.
3. Pour through the thistle-tube 5^{cc} dilute H₂SO₄ (half water and half acid). Add more if needed.

64. CHLORINE WATER.

Ap. : 2 t.t.

Ch. : 3 or 4 crystals KClO_3 , few drops HCl , 2^{cc} cochineal sol., 2^{cc} $\text{K}_2\text{Cr}_2\text{O}_7$ sol., Turkey red cloth.

1. Drop into a t.t. 3 or 4 crystals of KClO_3 .
2. Add a few drops of HCl ; hold in the flame for a minute, and when action begins add 5 or 10^{cc} H_2O . Cautiously take the odor.
3. To 2^{cc} indigo sol. in a t.t. add a little Cl water. Is the color discharged?
4. To 2^{cc} cochineal sol. in a t.t. add a little Cl water. Is the solution bleached? Try also litmus sol.
5. To 2^{cc} $\text{K}_2\text{Cr}_2\text{O}_7$ sol. in a t.t. add a little Cl water. Is this bleached?
6. $\text{K}_2\text{Cr}_2\text{O}_7$ is a mineral pigment; cochineal is animal. Explain the results.
7. Try to bleach a piece of Turkey red cloth by putting it into some Cl water.



65. TO MAKE BROMINE.

Ap. : r.s., lamp, 2 t.t., d.t., rec.

Ch. : 1^s KBr, 1^s MnO, 5^{cc} H₂SO₄, 5^{cc} HCl, cloth, etc. (to bleach).

1. Mix 1^s KBr crystals, and 1^s MnO₂; transfer them to a t.t., and add 3^{cc} H₂SO₄.
2. Attach a d.t. and pass the other end of it to the bottom of a t.t. surrounded by a rec. of water.
3. Hang the apparatus on a r.s., and heat it slowly. Avoid getting Br vapor into the air of the room, as it is very irritating to the eyes.
$$\text{MnO}_2 + 2 \text{KBr} + 3 \text{H}_2\text{SO}_4 = ?$$
$$\text{MnO}_2 + 2 \text{KBr} + 2 \text{H}_2\text{SO}_4 = ?$$
4. Notice the color of the gas and the liquid; also the sp. gr. of the gas, by pouring some into a rec. Test the bleaching action of this on cloth.
5. Sift a bit of fine Sb, As, or Cu into the gas, and look for combustion. Clean the t.t. by heating HCl with the residue.

66. TO MAKE IODINE.

Ap. : lamp, 2 t.t., rec., e.d., st.r.

Ch. : 1^s KI, 1^s MnO₂, 1^s starch, paper, 3^{cc} H₂SO₄.

1. Generate I in this experiment like Br in the previous one, substituting KI for KBr. Reactions.
2. Put 1^s of fine starch into an e.d., add 2 or 3 drops of water, mix them; then pour on 5^{cc} of boiling water from a t.t., and stir the mixture. This makes starch paste.
3. Dip some strips of paper into the starch sol., and save for testing I. Hold one in the I vapor of this experiment, and note the color imparted to it. This is the test for I. What would be the test for starch?



67. SUBLIMATION OF IODINE.

Ap. : t.t., st.r.

Ch. : 4 or 5 crystals I.

1. Warm 1 or 2 crystals of I in a dry t.t. Notice the color of the vapor, and its sp. gr., by pouring some of it into the air.
2. Hold a st.r. half way down the t.t. while warming the tube. Look for a sublimate on the sides of the t.t. and on the rod, and observe the crystals of I.

68. SOLUTION OF IODINE.

Ap. : t.t.

Ch. : few crystals I, 5^{cc} C₂H₅OH, starch-papers.

1. Put 3 or 4 crystals of I into a t.t., and add 3 or 4^{cc} alcohol, C₂H₅OH.
2. Warm a minute and observe the solution. This is tincture of I. Add a drop of this with a st.r., to a drop of starch sol. shaken up with 10 or 15^{cc} H₂O. Observe the color. Boil it for a minute to see whether the color disappears. If not, too much I was added. Observe again when it is cool.
3. Try to dissolve 2 or 3 crystals of I in 2^{cc} H₂O in a clean t.t. Warm it.
4. See whether any is dissolved, by using the starch test as above.

69. TEST FOR IODINE.

Ap. : 2 t.t.

Ch. : 5% KI sol., starch sol., KClO_3 , HCl.

1. Prepare 5% Cl water (Exp. 64) in a t.t.
2. Put into a clean t.t. 5% KI sol., and add a drop of starch sol. Shake them well together.
3. Now add a drop or two of Cl water, and notice the change of color. Explain and give reaction.



70. CRYSTALLIZATION OF SULPHUR.

Ap. : 1 beaker (25 or 50^{cc}), r.s., plate, asbestos, lamp, e.d.

Ch. : 15^g S (brimstone), 3^{cc} HNO₃.

1. Into a small beaker put 15^g S, and slowly melt it over a lamp. Note the color.
2. When melted, extinguish the light, and leave the beaker in position till it is cool enough not to break. Then remove it and watch the solidification of the S. When half solid, pour out the res. into an e.d. of water.
3. Look for crystals of S in the beaker.
4. Loosen the S by pouring round the edges a little HNO₃. Warm if necessary, when the mass may be removed by a thin knife-blade.

71. ALLOTROPY OF SULPHUR.

Ap. : lamp, e.d., t.t.

Ch. : 10^g S, 3^{cc} HNO₃.

1. Put 10^g S into a t.t. and slowly melt it. Notice the yellow color, and see that the liquid is very thin. It is now somewhat above 100°.
2. Heat it more strongly till it becomes black. Note it is now very thick and cannot be poured. It is about 200°.
3. Apply more heat till it grows thin again. It is above 300°.
4. Now heat to boiling (over 400°), note the color of the vapor and any sublimate on the t.t.
5. Pour the S into an e.d. of water. Knead it, and note its elasticity. See that it afterwards changes.
6. Clean the t.t. as before.

72. HYDROGEN SULPHIDE.

Ap. : 2 t.t., d.t., filter paper, funnel.

Ch. : 5^g FeS, 5^{cc} HCl or H₂SO₄, few drops Pb(C₂H₃O₂)₂ sol.,
Ag and Cu coins, lit.

1. Put into a rec. or a t.t. 5^g FeS, 10^{cc} H₂O and 5^{cc} HCl (or H₂SO₄). Equation.
2. Adjust a d.t. and pass the gas, for a minute or two, into 5^{cc} H₂O in another t.t. Have the bearings tight.
3. See whether this sol. is acid, alkaline, or neutral. Use both colors of lit.
4. With a str. put a drop of the H₂S sol. on Ag and Cu coins. Reactions.
5. Put a drop of Pb(C₂H₃O₂)₂ sol. on paper, and hold it in the vapor of H₂S. This is the characteristic test for H₂S.

73. HYDROGEN SULPHIDE AS A REAGENT.

Ap. : H_2S gen.

Ch. : Sol. AgNO_3 , $\text{Pb}(\text{NO}_3)_2$, $\text{Ba}(\text{NO}_3)_2$, Na_2CO_3 (4^{cc} each), H_2S .

1. Pour 2^{cc} AgNO_3 sol. into a clean t.t., add 5^{cc} H_2O , shake it, and pass a little H_2S gas into it. Reaction. What is the ppt.?
2. Do the same with $\text{Pb}(\text{NO}_3)_2$ sol. Equation.
3. Do the same with $\text{Ba}(\text{NO}_3)_2$ sol. Why is there no equation?
4. Mix 2^{cc} $\text{Pb}(\text{NO}_3)_2$ sol. and 2^{cc} $\text{Ba}(\text{NO}_3)_2$ sol., 5^{cc} H_2O ; shake them and pass H_2S gas into the liquid for two or three minutes. Which metal is pptd.? Equation.
5. Filter, and add to the filtrate 2 or 3^{cc} Na_2CO_3 sol. What is the ppt.? Equation.

74. SPONTANEOUS COMBUSTION OF PHOSPHORUS.

Ap. : e.d.

Ch. : 10^{cc} CS₂, paper, P (size of pea).

1. Into an e.d. put 10^{cc} CS₂, and drop into it 2 or 3 small pieces of P. This is enough for a class. Notice the odor of CS₂, and the solubility of P.
2. Dip a piece of unglazed paper into the sol., hold it in the air till it is dry, and look for any action. Explain fully.

75. COMBUSTION UNDER WATER.

Ap. : t.t., rec., thistle-tube.

Ch. : few crystals KClO_3 , 3^{cc} H_2SO_4 , P (usual size).

1. Put into a t.t. 4 or 5 crystals of KClO_3 and 3^{cc} H_2O , and a bit of P, half the size of a pea.
2. Rest the t.t. in a rec., then slowly add 2 or 3^{cc} H_2SO_4 , through a thistle-tube watching for any combustion. Explain.

76. SUBLIMATION OF ARSENIC.

Ap. : i.t. (10^{cm} long, $\frac{1}{2}$ ^{cm} diam.), lamp.

Ch. : As_2O_3 (very small bit), charcoal (fragment).

1. Prepare a small, pointed i.t., and put into the bottom a bit of As_2O_3 , not larger than a grain of wheat.
2. Above this, at a little distance, insert a fragment of charcoal.
3. First heat the coal to redness, then heat the As_2O_3 so the fumes will go over the hot coal. Note the odor of the escaping As. Keep the coal hot.
4. Look for a sublimate (metallic mirror) above the coal.
5. Break the tube with a jet of water, and examine the sublimate. What is it? Equation.



77. TO MAKE SILICA FROM WATER GLASS.

Ap. : e.d., r.s., lamp, st.r.

Ch. : 5^{cc} Na₄SiO₄, 5^{cc} HCl, 10^{cc} NaOH sol.

1. Put into an e.d. 5^{cc} Na₄SiO₄ (or K₄SiO₄), and add **the same** volume of HCl. Describe the effect.
 $\text{Na}_4\text{SiO}_4 + 4 \text{HCl} = ?$
2. Pour off any excess of HCl, and evaporate the residue over a flame or a water-bath. $\text{H}_4\text{SiO}_4 - 2 \text{H}_2\text{O} = ?$
3. When the residue becomes white, cool it, add 10^{cc} H₂O, and stir it for a minute; then taste a drop, and pour off the water.
4. What is the residue? Crush a little with the fingers, and compare it with any substance you have seen before.
5. Remove any that adheres to the e.d. with strong NaOH sol., by boiling. SiO₂ is soluble in NaOH sol.

78. GUNPOWDER.

Ap. : lamp, brick.

Ch. : 4^s KNO₃ (or NaNO₃), $\frac{1}{2}$ ^s S, $\frac{1}{2}$ ^s charcoal.

1. Pulverize separately and very finely 4^s KNO₃ (or NaNO₃), $\frac{1}{2}$ ^s S, $\frac{1}{2}$ ^s charcoal, and mix them intimately on paper or in a mortar.
2. Pile the mixture on a brick, and apply a lighted match. $2 \text{ KNO}_3 + 3 \text{ C} + \text{S} = ?$
3. Remove the adhering product by soaking in water.

79. ACTION OF SOAP ON HARD WATER.

Ap. : t.t., e.d.

Ch. : 2^s hard soap, 10^{cc} CaSO₄ (or MgSO₄) sol.

1. Dissolve in a t.t., by boiling 1 or 2^s hard soap in 10 or 15^{cc} H₂O.
2. Add 10^{cc} of a clear solution of CaSO₄ or MgSO₄ (recently made), shake it, and look for a ppt. or any turbidity. An insoluble lime-soap has been formed.
3. Sodium $\left\{ \begin{array}{l} \text{stearate} \\ \text{palmitate} \\ \text{oleate} \end{array} \right\} + \text{calcium sulphate} = ?$

From this explain the action of hard water on soap.

80. COMBUSTION OF MAGNESIUM.

Ap. : lamp, forceps.

Ch. : Mg ribbon (3^{cm}).

1. Examine a piece of Mg ribbon, and describe, noting any tarnish.
2. With the forceps hold it in a flame till it begins to burn. Notice the color and intensity of the light.
3. Observe the product, and name it. Equation.



**81. TO OXIDIZE FERROUS TO FERRIC
SALTS (Fe^{II} to Fe^{IV}).**

Ap. : 2 t.t.

Ch. : 10^{cc} FeSO_4 sol., 5^{cc} NaOH or NH_4OH , 1^{cc} HNO_3 .

1. Into each of 2 t.t. put 5^{cc} FeSO_4 sol. (recently prepared).
2. To one of these add 1^{cc} HNO_3 , and boil a minute.
3. Add to each 5^{cc} NaOH sol. or NH_4OH . Reactions.
4. Explain the oxidation and the difference of colors, and see whether either hydrate tends to change to the other by standing. FeSO_4 has been oxidized to $\text{Fe}_2(\text{SO}_4)_3$.

**82. TO REDUCE FERRIC TO FERROUS SALTS
(Fe^{IV} to Fe^{II}).**

Ap. : 4 t.t., d.t.

Ch. : 5^{cc} FeSO₄ sol., HNO₃, NH₄OH, 2^g Cu, 5^{cc} H₂SO₄.

1. Oxidize 5^{cc} FeSO₄ sol. with 1^{cc} HNO₃, by boiling, as in Exp. 81, and dilute it with its volume of water.
2. Pour a little of this into another t.t., add to it NH₄OH, and note the color of the ppt.
3. Pass SO₂ gas from a gen. (Cu and H₂SO₄ heated in a t.t.), into the other portion for a few minutes.
4. Next add NH₄OH, and note the color of the ppt. Compare it with the previous product. Fe₂(SO₄)₃ has been reduced to FeSO₄, if the action continued long enough.

83. TO MAKE LEAD SALTS.

Ap. : 3 t.t.

Ch. : 55^{cc} $\text{Pb}(\text{NO}_3)_2$ sol., 5^{cc} sol. of each of these :
 $(\text{NH}_4)_2\text{S}$, K_2CrO_4 , H_2SO_4 , KI , KBr , NaCl , NaOH ,
 Na_2SO_3 , Na_2CO_3 , KCN , $\text{K}_4\text{Fe}(\text{CN})_6$.

Add 5^{cc} $\text{Pb}(\text{NO}_3)_2$ sol. to each of the following in a clean t.t. Give the color of each product, name it, and write the reaction for its production. State whether a ppt. is produced. Tubes may be cleaned by the use of water and a swab.

- (a) 5^{cc} $(\text{NH}_4)_2\text{S}$.
- (b) 5^{cc} K_2CrO_4 sol.
- (c) 5^{cc} H_2SO_4 .
- (d) 5^{cc} KI sol.
- (e) 5^{cc} KBr sol.
- (f) 5^{cc} NaCl sol.
- (g) 5^{cc} NaOH sol.
- (h) 5^{cc} Na_2SO_3 sol.
- (i) 5^{cc} Na_2CO_3 sol.
- (j) 5^{cc} KCN sol.
- (k) 5^{cc} $\text{K}_4\text{Fe}(\text{CN})_6$ sol.

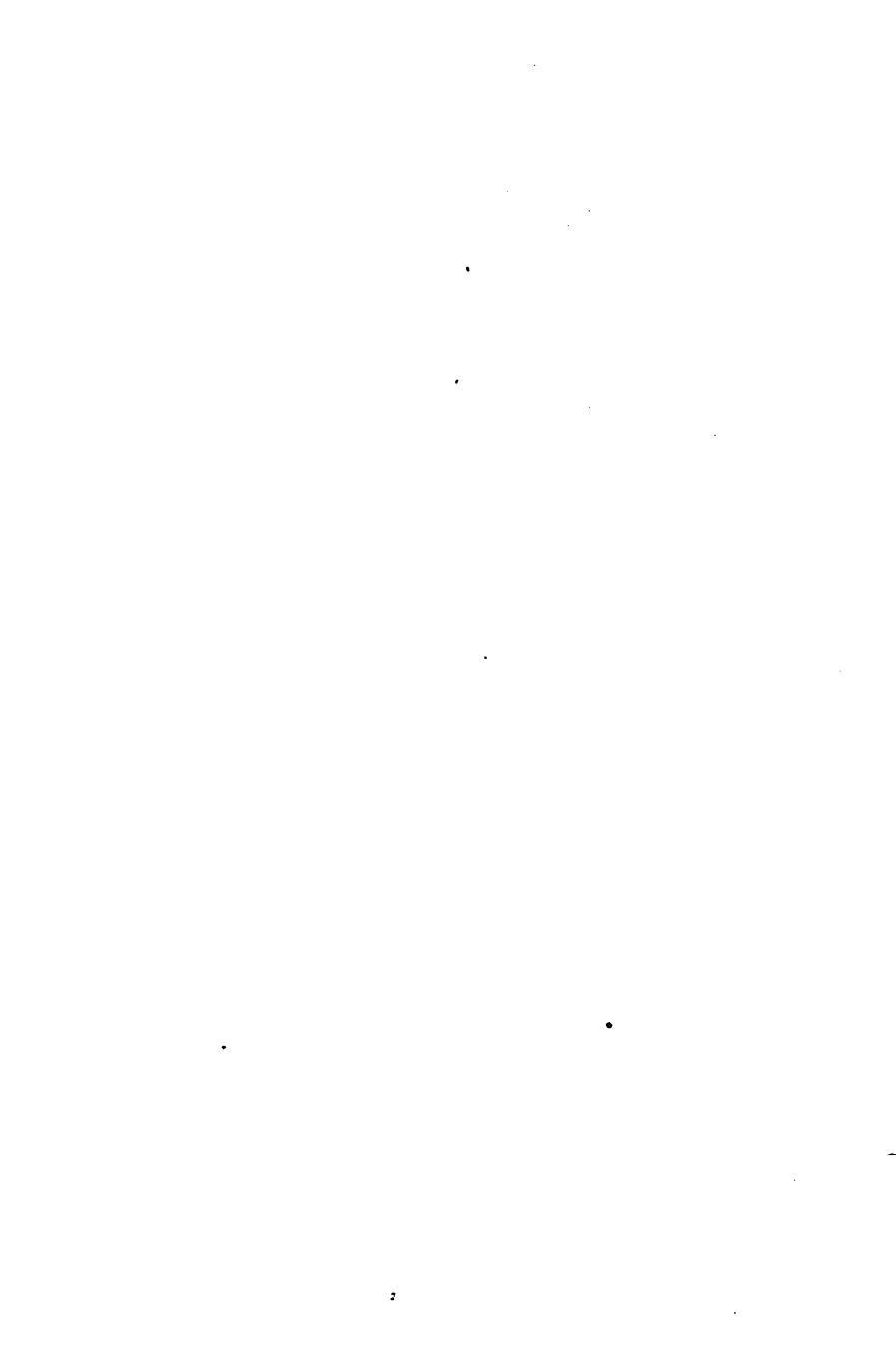


84. TO ILLUSTRATE PHOTOGRAPHY.

Ap. : 2 t.t., filter paper, funnel, st.r., rec.

Ch. : 2^{cc} AgNO₃ sol., 4^{cc} NaCl sol., 10^{cc} Na₂S₂O₃ sol.

1. Put into each of 2 t.t. 10^{cc} H₂O, 1^{cc} AgNO₃ sol., and 2^{cc} NaCl sol.; shake, and notice the color. What is the product? Reaction.
2. Filter one of them, and wash the residue well with water, by pouring water on it, and allowing the water to run through the filter. Reject the wash-water. Then open the filter paper, and expose the residue to direct sunlight. Presently stir it, and observe the change of color produced by the light. $2 \text{ AgCl} - \text{Cl} = ?$
3. Add to the other portion 5^{cc} Na₂S₂O₃ sol. Shake it, and notice whether the ppt. dissolves. If not, add more *hypo*.



85. TO ILLUSTRATE PHOTOGRAPHY.

Ap. : 2 t.t., filter paper, funnel.

Ch. : 2^{cc} AgNO₃ sol., 4^{cc} KBr sol., 10^{cc} Na₂S₂O₃ sol.

1. Put into each of 2 t.t. 10^{cc} H₂O, 1^{cc} AgNO₃ sol., and 2^{cc} KBr sol. Shake, and filter the contents of one, and wash the residue. Reaction. Expose to direct sunlight, and observe the change of color. $2 \text{AgBr} - \text{Br} = ?$
2. To the other add Na₂S₂O₃ sol. till the ppt. dissolves.

86. DESTRUCTIVE DISTILLATION OF WOOD.

Ap. : lamp, plate, i.t. (10^{cm} long, 1 or 1½^{cm} diam.).

Ch. : wood shavings.

1. Half fill an i.t. with wood shavings closely packed.
2. Hold it steadily over a lamp to heat it, meantime trying to ignite the escaping gas. Note the color of the flame, and see whether any soot is deposited on an e.d. held in the burning gas.
3. Break, and examine the tube for a tarry residue, and for coal.
4. Put the coal on an iron plate and bring a Bunsen flame in contact with it, noting whether it burns with a flame, or only glows. Only gas burns with flame.
5. Write no reactions, but state how many and what products you observed in this experiment.

87. ILLUMINATING GAS.

Ap. : i.t. (10^{cm} long, 1 or 1½^{cm} diam.), lamp, plate.

Ch. : 5^s cannel coal (granular masses).

1. Fill an i.t. $\frac{1}{2}$ full of cannel (or bituminous) coal.
2. Perform this experiment like the previous one, apply the same tests throughout, and notice and describe all the products. Heat strongly and as long as any gas separates.

88. ALCOHOL.

Two pupils may work together.

Ap. : apparatus for distilling, t.t., d.t., flask.

Ch. : 20^{cc} molasses, half a cake of yeast.

1. Put 20^{cc} molasses into a flask (of 200^{cc}), fill it with water to the neck, and put in half a cake of yeast.
2. Fit to it a d.t., and pass the end into a t.t. holding some clear lime water. Leave it in a warm place for two or three days.
3. Look for any turbidity in the lime water, and account for it. See whether the liquid in the flask is sweet.
4. Attach the flask to an apparatus for distilling water, and pass over not more than one-fifth of the liquid by distillation.
5. Taste and smell the distillate. Re-distil it if desired, passing over not more than half of it.

89. VEGETABLE PARCHMENT.

Ap. : e.d.

Ch. : 12^{cc} H₂SO₄, filter papers.

1. Pour into an e.d. 5^{cc} H₂O, add 12^{cc} H₂SO₄ (measure each), and stir the mixture.
2. *When it becomes cold*, dip a strip of unglazed paper (filter paper) into the liquid, and leave 15 seconds. One end of the paper should be out of the liquid, in order to remove it quickly.
3. At once rinse it thoroughly with water, then let it dry.
4. If the fibre is not toughened, try again, using new paper and varying the time a little.



90. TO SEPARATE SILVER FROM COPPER.

Ap. : 2 t.t., funnel, filter papers, rec.

Ch. : 5^{cc} sol. AgNO_3 and 5^{cc} sol. $\text{Cu}(\text{NO}_3)_2$, 5^{cc} HCl , H_2S gen.

1. Pour into a t.t. 5^{cc} AgNO_3 sol. and 5^{cc} $\text{Cu}(\text{NO}_3)_2$ sol. Shake them together.
2. Add HCl till no more ppt. continues to form, then pour it on a filter. Save the filtrate. Reaction for AgNO_3 . $\text{Cu}(\text{NO}_3)_2$ is unchanged.
3. See whether all the Ag is ppd. by adding 2 or 3 drops of HCl to the filtrate. If a ppt. occurs, add more, and filter again.
4. Note what the *residue* is, and what the *filtrate* contains.
5. Pass into the filtrate some H_2S gas. (Exp. 72.) Reaction. This ppts. CuS .
6. Filter. What is the residue? What metals have been separated?

91. ANALYSIS OF A SILVER COIN.

Ap. : e.d., lamp, H_2S gen.

Ch. : ten-cent coin, 5°HNO_3 , 20°HCl , 5°FeS .

1. Put a ten-cent Ag coin into an e.d., and pour over it a mixture of 5°HNO_3 and $10^\circ \text{H}_2\text{O}$. Warm it till all or nearly all has dissolved.
2. Remove any that is undissolved, and pour the liquid into a t.t. Add HCl as long as a ppt. continues to form, then filter. AgCl is the residue. Reaction.
3. Add a drop or two of HCl to the filtrate, and, if a ppt. falls, add more, and filter again, to remove all the Ag.
4. Evaporate the filtrate to a few drops in an e.d. (to remove any free HNO_3), then add H_2O and pass H_2S gas into the filtrate so long as a ppt. forms. This is CuS . Reaction. Filter. The coin is thus found to contain Ag and Cu. This experiment is an example of qualitative analysis.

92. ANALYSIS OF TIN-FOIL.

Ap. : 3 or 4 t.t., lamp.

Ch. : HNO_3 , HCl , H_2SO_4 , K_2CrO_4 sol., $(\text{NH}_4)_2\text{S}$, HNa_2PO_4 sol., tin-foil.

1. Cover a small piece of tin-foil in an e.d. with 1 part HNO_3 to 5 parts water, enough to dissolve it, or nearly so. Warm the mixture.
2. Filter if necessary, and add its bulk of H_2O to the filtrate, then slowly add HCl till no more ppt., PbCl_2 , falls. Filter and set aside the filtrate (for 4). Reaction.
3. Pour boiling water on the residue, and let it run through into a clean t.t. If it is not clear, boil a minute, then divide it into two parts. To one add a little K_2CrO_4 sol.; to the other add H_2SO_4 . The ppts. are PbCrO_4 and PbSO_4 . These prove the presence of Pb. Reactions.
4. Evaporate in an e.d. the filtrate (from 2) to a few drops (to remove free acid), then add some H_2O and saturate it with H_2S : black ppt. is SnS . To prove it is Sn, filter, pour on res. a very little boiling dil. HCl , which dissolves SnS as SnCl_2 . Then add HgCl_2 sol.: white ppt. is HgCl , gray is Hg, either of which shows presence of Sn.

93. ANALYSIS OF FIRST GROUP METALS.

Pb, Hg(ous), Ag.

Solutions : $\text{Pb}(\text{NO}_3)_2$, HgNO_3 , AgNO_3 .

Reagents : dil. HCl , $\text{K}_2\text{Cr}_2\text{O}_7$ sol., NH_4OH , HNO_3 .

1. To 5^{cc} of a mixture of the above solutions add dil. HCl till the ppt. does not increase, then shake : ppt. contains PbCl_2 , HgCl , AgCl . Filter and reject the filtrate.
2. Wash the res. several times with cold water and reject the washings. Then add 10^{cc} boiling H_2O to the res. : filtrate contains PbCl_2 ; res. is HgCl and AgCl .
3. Add to filtrate $\text{K}_2\text{Cr}_2\text{O}_7$ sol. : yellow ppt. is PbCrO_4 .
4. Pour on the res. (from 2) NH_4OH : sol. contains $(\text{NH}_3)_3(\text{AgCl})_2$; black res. is $\text{NH}_2\text{Hg}_2\text{Cl}$.
5. To filtrate add HNO_3 : ppt. is AgCl . The three metals have thus been separated. Reactions may be omitted in the analyses.



94. ANALYSIS OF SECOND GROUP METALS, A.

Hg(1c), Pb, Bi, Cd, Cu.

Solutions: $\text{Hg}(\text{NO}_3)_2$, $\text{Pb}(\text{NO}_3)_2$, $\text{Bi}(\text{NO}_3)_3$, $\text{Cd}(\text{NO}_3)_2$,
 $\text{Cu}(\text{NO}_3)_2$.

Reagents: H_2S , HNO_3 , dil. HNO_3 , HCl , dil. H_2SO_4 , SnCl_2
sol., NH_4OH , KCN sol.

1. Into 5^{cc} of the sol. pass H_2S gas to sat.: ppt. is HgS , PbS , Bi_2S_3 , CdS , CuS . Filter, then wash the res. repeatedly till the wash-water gives no ppt. when a drop of AgNO_3 sol. is added.
2. Open the filter paper and remove the res. with a spatula to an e.d. Cover it well with dil. HNO_3 , and boil it a minute or two: insoluble res. is HgS and S (S is set free); sol. contains $\text{Pb}(\text{NO}_3)_2$, $\text{Bi}(\text{NO}_3)_3$, $\text{Cd}(\text{NO}_3)_2$, $\text{Cu}(\text{NO}_3)_2$. Decant it upon a filter, leaving the res. in the e.d.
3. Cover the res. with aqua regia, newly made, and stir it: sol. contains HgCl_2 ; yellow or black insol. res. is S . Filter and add to the filtrate SnCl_2 sol.: white ppt. is HgCl ; gray ppt. is Hg .
4. To filtrate (from 2), add a very little dil. H_2SO_4 , shake, and let it stand a few minutes: white ppt. is PbSO_4 . Filter.
5. Add to filtrate NH_4OH : flaky white ppt. is $\text{Bi}(\text{OH})_3$. Filter. Filtrate contains $\text{Cd}(\text{OH})_2$ and $\text{Cu}(\text{OH})_2$; blue color indicates Cu .
6. Add to filtrate KCN sol. till the blue color disappears, then sat. with H_2S : yellow ppt. is CdS ; sol. contains $(\text{KCN})_2\text{Cu}(\text{CN})_2$.
7. Filter and acidify filtrate with HCl : black ppt. is CuS .



95. ANALYSIS OF SECOND GROUP METALS, B.

As, Sn, Sb.

Solutions: Na_3AsO_3 , SnCl_2 , SbCl_3 (dissolved in H_2O and HCl).

Reagents: $\text{H}_2\text{S}(\text{NH}_4)_2\text{CO}_3$ sol., HCl , KClO_3 , Pt , Zn , HgCl_2 sol., HNO_3 , $\text{H}_2\text{C}_4\text{H}_4\text{O}_6$ sol.

1. Sat. 5^{cc} of the sol. with H_2S : ppt. is As_2S_3 , SnS , Sb_2S_3 . Filter and wash.
2. Add to the res. in an e.d. $(\text{NH}_4)_2\text{CO}_3$ sol. and stir it well: sol. contains $(\text{NH}_4)_3\text{AsO}_3$ and $(\text{NH}_4)_3\text{AsS}_3$. Filter and wash.
3. Acidify filtrate with HCl : yellow ppt. is As_2S_3 .
4. To res. (from 2), in an e.d., add a little HCl (avoid excess) and two or three crystals of KClO_3 , then boil: sol. contains SnCl_2 and SbCl_3 .
5. Dilute the sol. and put in a piece of Pt foil and a piece of Zn in contact: white ppt. on the metals is Sn , black is Sb ; sol. contains ZnCl_2 .
6. When action has nearly ceased, pour off the liquid and carefully wash the metals, then add a little HCl : sol. contains SnCl_2 (and ZnCl_2).
7. Decant upon a filter and add to the filtrate HgCl_2 sol.: white ppt. is HgCl , gray is Hg .
8. Carefully wash the black res. in the e.d., then add a little $\text{H}_2\text{C}_4\text{H}_4\text{O}_6$ sol. with a few drops of HNO_3 : sol. contains Sb_2O_3 and $(\text{SbO})_2\text{C}_4\text{H}_4\text{O}_6$. Filter from impurities.
9. Treat filtrate with H_2S : orange ppt. is Sb_2S_3 .

96. ANALYSIS OF THIRD GROUP METALS.

Fe, Al, Cr.

Solutions : FeSO_4 , $\text{K}_2\text{Al}_2(\text{SO}_4)_4$, $\text{K}_2\text{Cr}_2\text{O}_7$.

Reagents : NH_4OH , HNO_3 , HCl , KClO_3 , $\text{HC}_2\text{H}_3\text{O}_2$, $\text{C}_2\text{H}_5\text{OH}$,
 NaOH sol., $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$ sol.

1. To 5^{cc} of the sol. add a few drops of HNO_3 and boil for an instant: yellow color shows oxidation of FeSO_4 to $\text{Fe}_2(\text{SO}_4)_3$.
2. Add a few drops of HCl and of $\text{C}_2\text{H}_5\text{OH}$ and carefully boil a minute or two, then leave till chemical action ceases: green color shows $\text{K}_2\text{Cr}_2\text{O}_7$ is reduced to Cr_2Cl_6 .
3. Alkalize the sol. with NH_4OH : ppt. is $\text{Fe}_2(\text{OH})_6$, $\text{Al}_2(\text{OH})_6$, $\text{Cr}_2(\text{OH})_6$. Filter and wash thoroughly.
4. Dissolve the res. in a little HNO_3 : sol. contains $\text{Fe}_2(\text{NO}_3)_6$, $\text{Al}_2(\text{NO}_3)_6$, $\text{Cr}_2(\text{NO}_3)_6$.
5. Boil the filtrate in a t.t. with a few crystals of KClO_3 until it is distinctly red, adding H_2O as it evaporates; shake the t.t. vigorously while boiling: sol. contains $\text{Fe}_2(\text{NO}_3)_6$, $\text{Al}_2(\text{NO}_3)_6$, $\text{K}_2\text{Cr}_2\text{O}_7$. ($\text{Cr}_2(\text{NO}_3)_6$ has been oxidized to $\text{K}_2\text{Cr}_2\text{O}_7$, which prevents its ppn. in 6 and 7.)
6. Add excess of NaOH sol.: reddish ppt. is $\text{Fe}_2(\text{OH})_6$; sol. contains $\text{Na}_2\text{Al}_2\text{O}_4$, Na_2CrO_4 . Filter.
7. Acidify filtrate with HCl , then alkalize with NH_4OH : white flaky ppt., which rises to the surface after standing, is $\text{Al}_2(\text{OH})_6$. (H_4SiO_4 , contained in the NaOH , may be ppd. here, but this on standing sinks to the bottom.) Filter.
8. Acidify filtrate with $\text{HC}_2\text{H}_3\text{O}_2$; add $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$ sol.: yellow or reddish ppt. is PbCrO_4 .



97. ANALYSIS OF FOURTH GROUP METALS.

Co, Ni, Mn, Zn.

Solutions : CoCl_2 , NiCl_2 , MnCl_2 , ZnCl_2 .

Reagents : $(\text{NH}_4)_2\text{S}$, dil. HCl , HCl , HNO_3 , $\text{HC}_2\text{H}_3\text{O}_2$, NaOH sol., KNO_3 sol.

1. To 5^{cc} of the sol. add $(\text{NH}_4)_2\text{S}$, shake and warm it, without boiling: ppt. is CoS , NiS , MnS , ZnS . Filter, then pour on the res. a few drops of $(\text{NH}_4)_2\text{S}$ (to prevent oxidation), and at once wash with hot water two or three times.
2. Transfer the res. to an e.d., pour on it dil. HCl , stir it well, then filter and wash: sol. contains MnCl_2 and ZnCl_2 ; res. is CoS and NiS .
3. Remove res. to an e.d. and dissolve in a little aqua regia: sol. contains CoCl_2 and NiCl_2 . Filter if necessary.
4. Add to the filtrate excess of NaOH sol.: ppt. is $\text{Co}(\text{OH})_2$ and $\text{Ni}(\text{OH})_2$. Filter.
5. Pour on res. $\text{HC}_2\text{H}_3\text{O}_2$: sol. contains $\text{Co}(\text{C}_2\text{H}_3\text{O}_2)_2$ and $\text{Ni}(\text{C}_2\text{H}_3\text{O}_2)_2$.
6. Add to the sol. a little KNO_3 sol.: yellow ppt. (complete only after several hours) is $\text{K}_6\text{Co}_2(\text{NO}_2)_{12}$.
7. Filter and add to filtrate excess of NaOH sol.; light flaky ppt. is $\text{Ni}(\text{OH})_2$.
8. Boil filtrate (from 2) to expel all H_2S , add excess of NaOH sol., shake well and warm it: brown ppt. is $\text{Mn}(\text{OH})_2$; sol. contains Na_2ZnO_2 . (Unless excess of strong NaOH sol. is added, white $\text{Zn}(\text{OH})_2$ is ppd.)
9. Filter, and acidify filtrate with $\text{HC}_2\text{H}_3\text{O}_2$: sol. contains $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2$.
10. Add $(\text{NH}_4)_2\text{S}$: ppt. (white if pure) is ZnS .

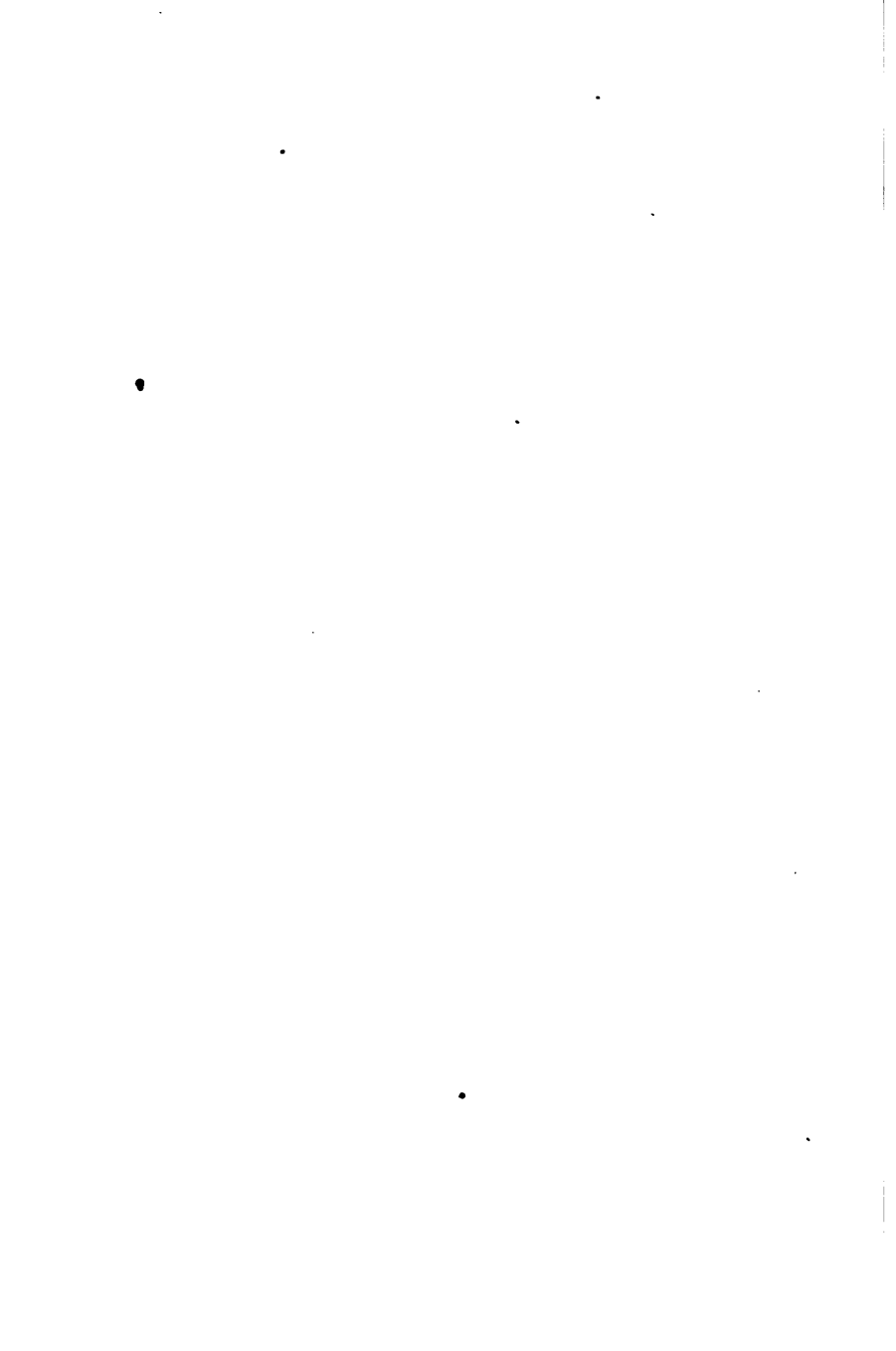
98. ANALYSIS OF FIFTH GROUP METALS.

Ba, Sr, Ca, Mg.

Solutions: BaCl_2 , SrCl_2 , CaCl_2 , MgCl_2 .

Reagents: NH_4OH , NH_4Cl sol., $(\text{NH}_4)_2\text{CO}_3$ sol., $(\text{NH}_4)_2\text{C}_2\text{O}_4$ sol., $\text{HC}_2\text{H}_3\text{O}_2$, HNa_2PO_4 sol., $\text{K}_2\text{Cr}_2\text{O}_7$ sol., $(\text{NH}_4)_2\text{SO}_4$ sol.

1. To 5^{cc} of the sol. add a little NH_4Cl sol. and NH_4OH , then excess of $(\text{NH}_4)_2\text{CO}_3$ sol. and warm it: ppt. is BaCO_3 , SrCO_3 , CaCO_3 ; sol. contains $\text{MgCO}_3(\text{NH}_4)_2\text{CO}_3$. Filter (save filtrate for 6) and wash with hot water.
2. Pour on the ppt. $\text{HC}_2\text{H}_3\text{O}_2$: sol. contains $\text{Ba}(\text{C}_2\text{H}_3\text{O}_2)_2$, $\text{Sr}(\text{C}_2\text{H}_3\text{O}_2)_2$, $\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2$.
3. Add $\text{K}_2\text{Cr}_2\text{O}_7$ sol.: yellow ppt. is BaCrO_4 .
4. Filter and add to filtrate $(\text{NH}_4)_2\text{SO}_4$ sol. and shake it well: white ppt. is SrSO_4 . (Unless $(\text{NH}_4)_2\text{SO}_4$ sol. is very dilute, CaSO_4 will be ppd. here.)
5. Filter and add to filtrate NH_4OH and $(\text{NH}_4)_2\text{C}_2\text{O}_4$ sol.: white ppt. is CaC_2O_4 .
6. To filtrate (from 1) add HNa_2PO_4 sol.: white ppt. is NH_4MgPO_4 .



99. SEPARATION OF GROUPS I.-V.

Solutions : Any mixtures of Groups I.-V. that do not form a ppt

Reagents : HCl, H_2S , $(\text{NH}_4)_2\text{S}$, NH_4Cl sol., NH_4OH .

1. To 5^{cc} of the sol. add dil. HCl: ppt. contains Group I. Filter, wash, and analyze this by Group I. (Test filtrate with HCl to be sure all is pptd.) Filtrate contains Groups II.-V.
2. Saturate the filtrate with H_2S : ppt. contains Group II., A and B. Filtrate contains Groups III.-V. Filter. (To separate A from B, wash the ppt., then warm it in an e.d. with $(\text{NH}_4)_2\text{S}$. Filter: res. contains II., A; filtrate contains II., B. Analyze by respective groups.)
3. To filtrate (after oxidizing Fe and reducing Cr by Group III.), add NH_4Cl and NH_4OH : ppt. contains Group III.; filter, wash, and analyze by Group III. Filtrate contains Groups IV., V.
4. To filtrate, add $(\text{NH}_4)_2\text{S}$: ppt. contains Group IV.; filter, wash, and analyze by Group IV. Filtrate contains Group V.
5. Analyze filtrate by Group V.

100. TESTS FOR MET. RADICALS.

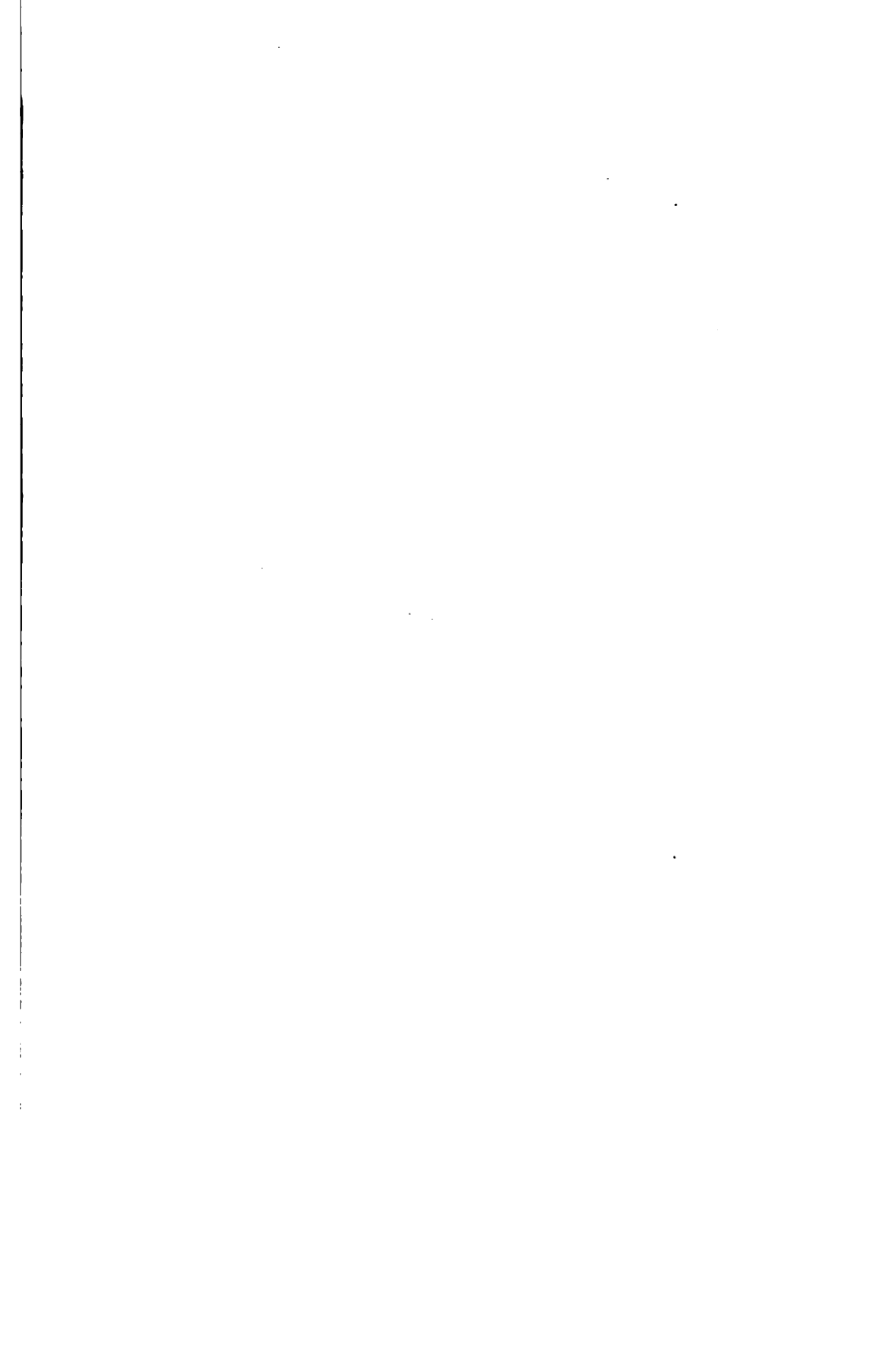
CL. BR. I. A. NO. SO. CO. PO.

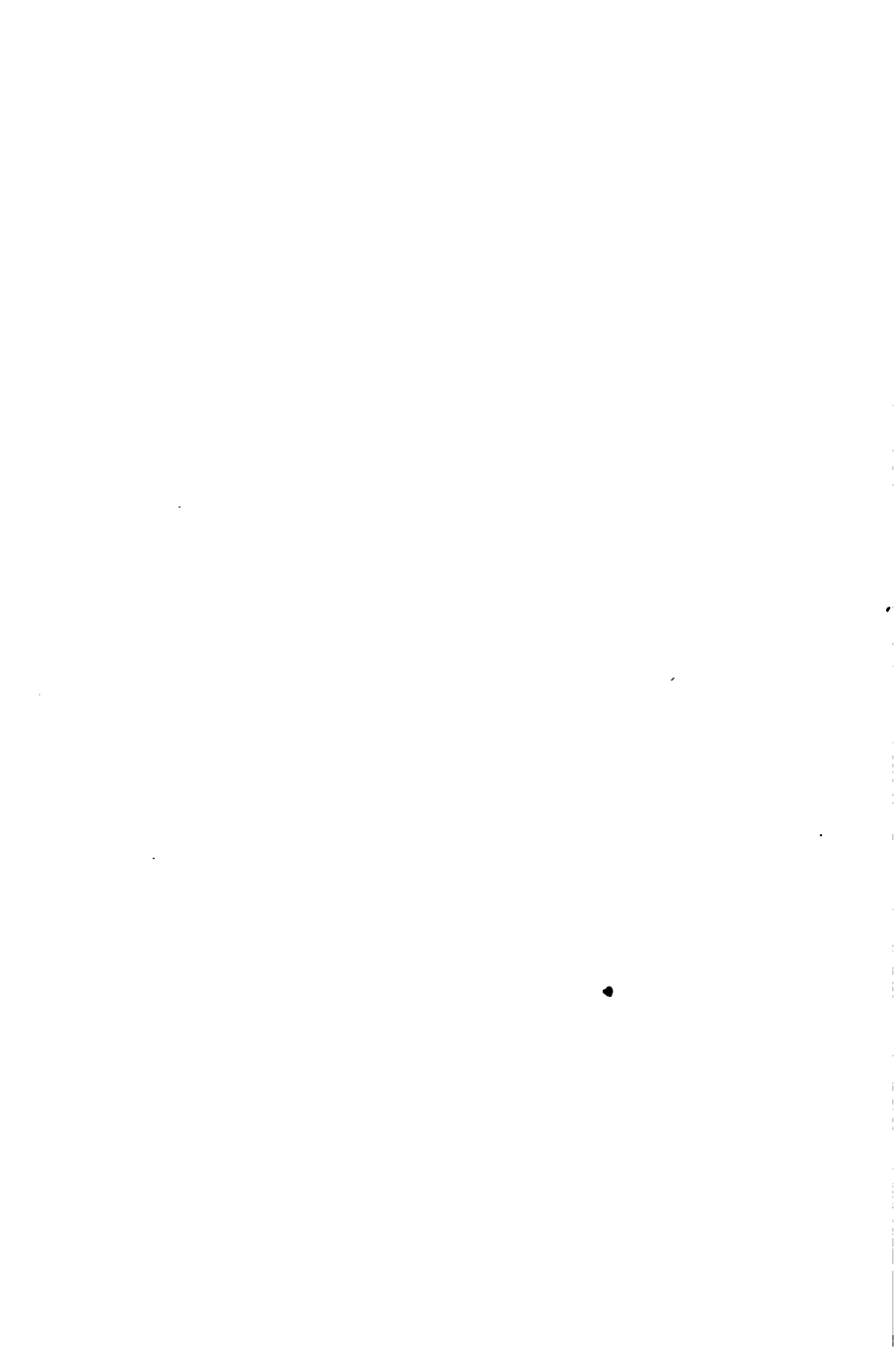
Acetates: NaCl sol. HCl sol. HNO_3 sol. H_2SO_4 sol. H_2O_2 sol.

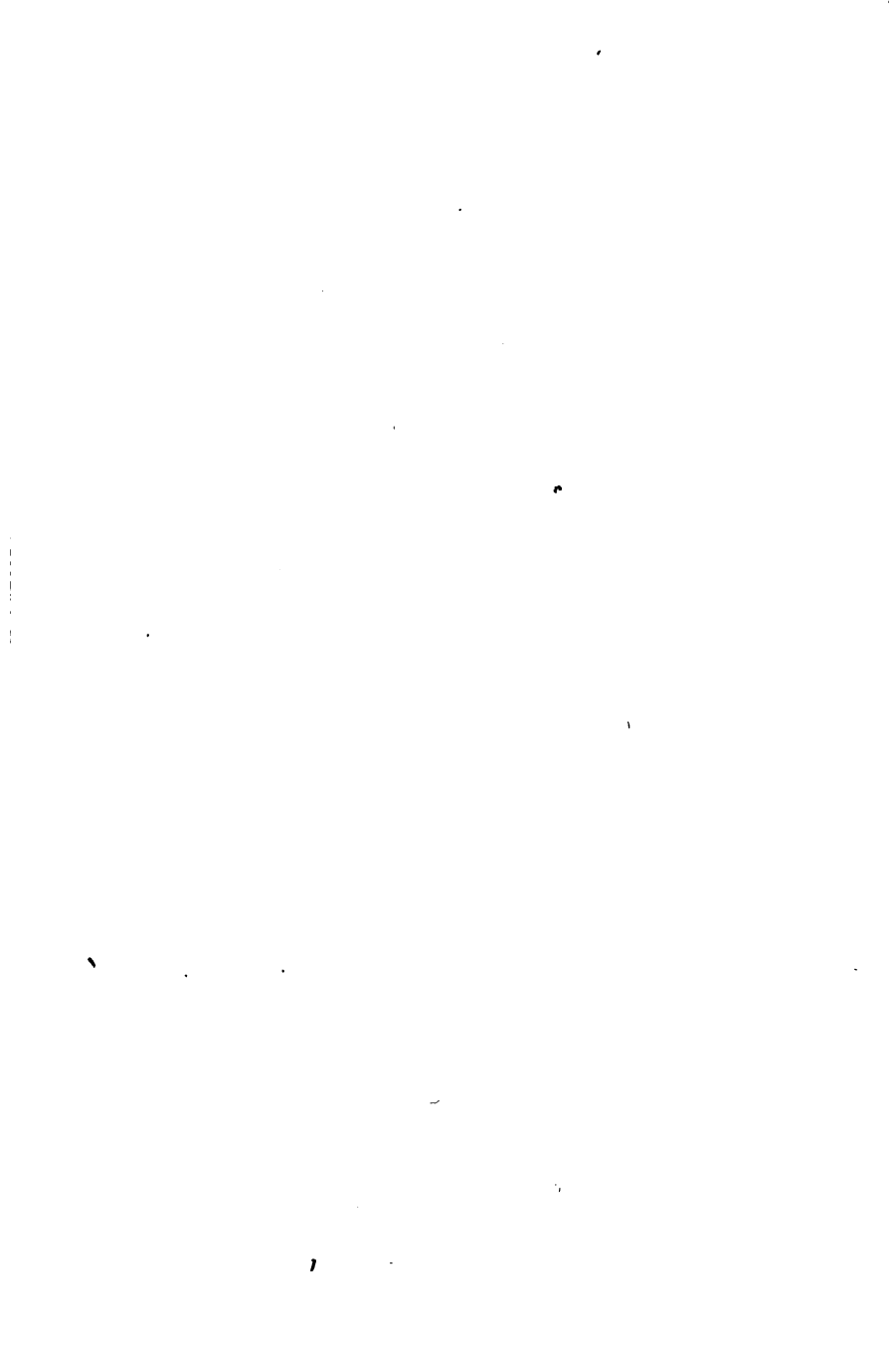
Acetates: AgNO_3 sol. NH_4OH sol. HCl sol. HNO_3 sol. H_2SO_4 sol. H_2O_2 sol. Ca(OH)_2 sol. NH_4Cl sol. MgSO_4 sol.

1. *Chlorides*, CL. To 5^{cc} NaCl sol. add a few drops AgNO_3 sol.: white ppt. is AgCl . soluble in NH_4OH .
2. *Bromides*, BR. To 5^{cc} KBr sol. add 2 or 3 drops of CS_2 , then dil. chlorine water, a few drops at a time, and shake well: the CS_2 at the bottom is yellow or reddish.
3. *Iodides*, I. To 5^{cc} KI sol. add 2 or 3 drops of CS_2 , then a very little dilute chlorine water, and shake it: the CS_2 at the bottom is violet.
4. *Sulphides*, S. To 5^{cc} Na_2S sol. add HCl ; put a drop of $\text{Pb(C}_2\text{H}_3\text{O}_2)_2$ sol. on paper and hold it over the Na_2S sol. as it is heated: black ppt. of metallic luster is PbS .
5. *Nitrates*, NO_3 . Mix 5^{cc} NaNO_3 sol. with a little H_2SO_4 and cool it: then pour down the side of the tube a little FeSO_4 sol.: brown or red ring is (FeSO_4).
6. *Sulphates*, SO. To 5^{cc} Na_2SO_4 sol. BaCl_2 sol. add: white ppt. is BaSO_4 , insoluble in HCl .
7. *Carbonates*, CO. To 5^{cc} Na_2CO_3 sol. add HCl : effervescence. To Ca(OH)_2 sol.: white ppt.
8. *Phosphates*, PO. To 5^{cc} Na_2PO_4 sol. add BaCl_2 sol.: white ppt.









100. TESTS FOR ACID RADICALS.

Cl, Br, I, S, NO₃, SO₄, CO₃, PO₄.

Solutions : NaCl, KBr, KI, Na₂S, NaNO₃, Na₂SO₄, Na₂CO₃, HNa₂PO₄.

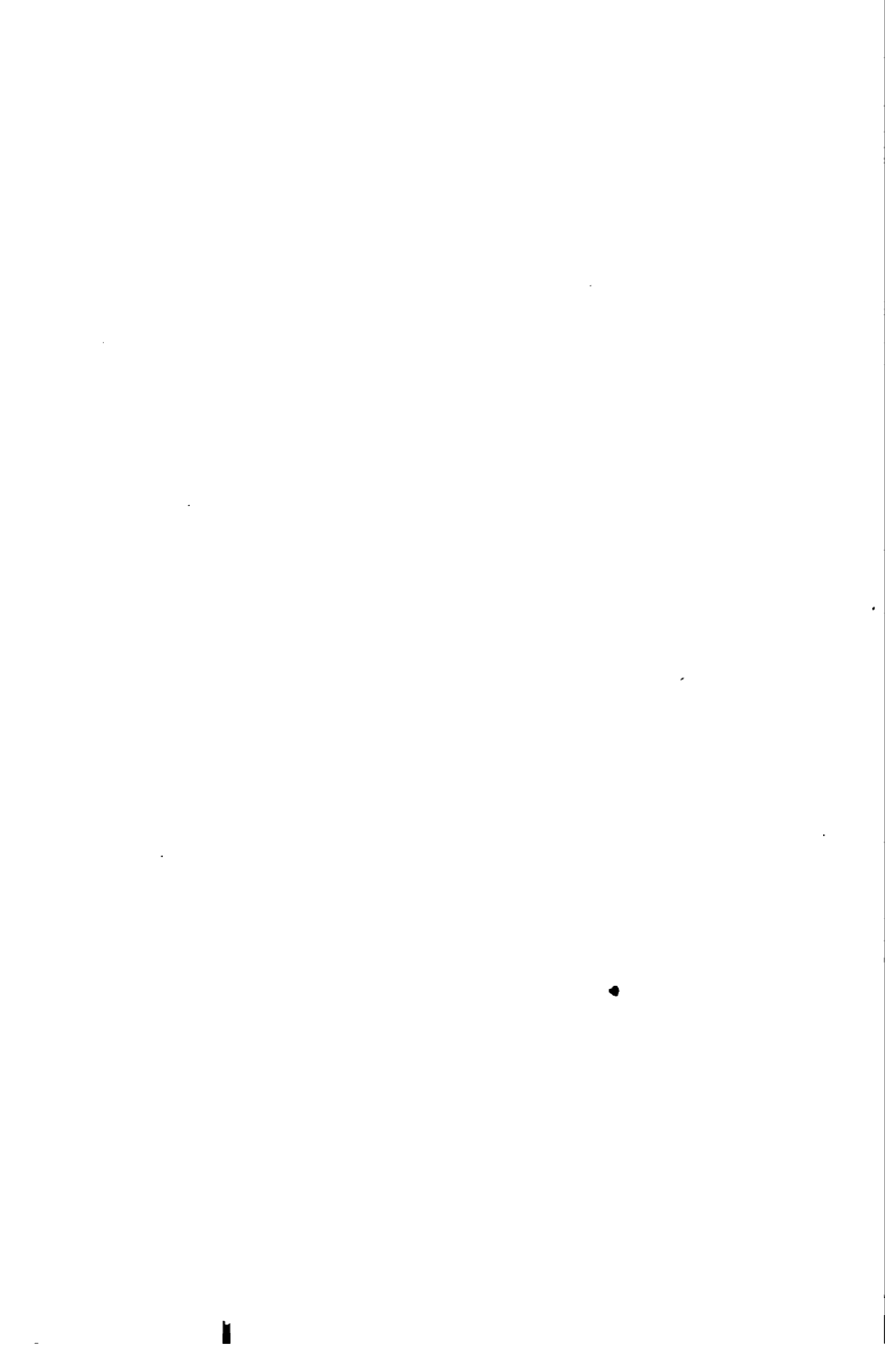
Reagents : AgNO₃ sol., NH₄OH, HCl, KClO₃, CS₂, Pb(C₂H₃O₂)₂ sol., H₂SO₄, FeSO₄ sol., BaCl₂ sol., Ca(OH)₂ sol., NH₄Cl sol., MgSO₄ sol.

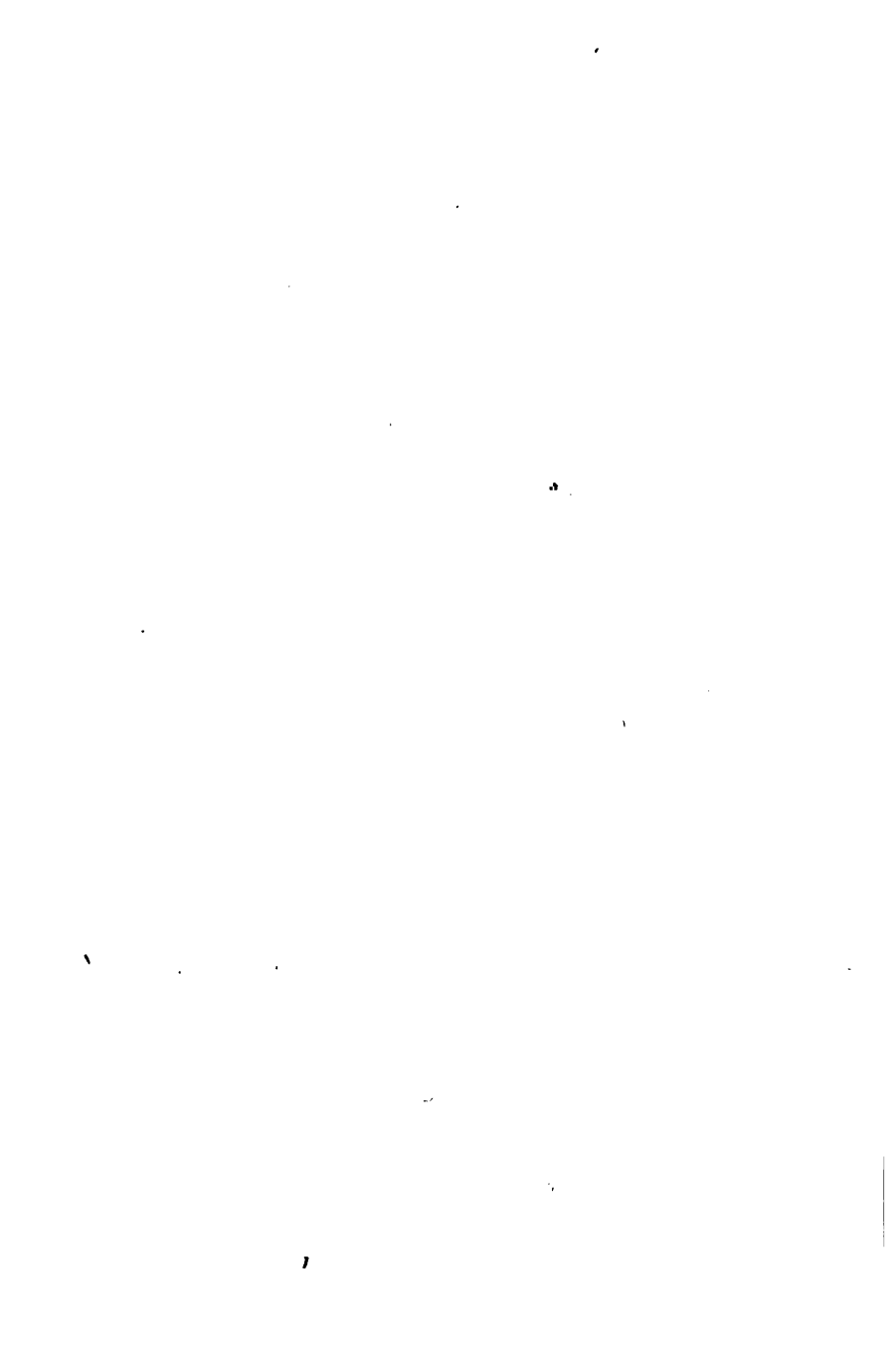
1. *Chlorides*, Cl. To 5^{cc} NaCl sol. add a few drops AgNO₃ sol. : white ppt. is AgCl, soluble in NH₄OH.
2. *Bromides*, Br. To 5^{cc} KBr sol. add 2 or 3 drops of CS₂, then dil. chlorine water, a few drops at a time, and shake well : the CS₂ at the bottom is yellow or reddish.
3. *Iodides*, I. To 5^{cc} KI sol. add 2 or 3 drops of CS₂, then a very little dilute chlorine water, and shake it : the CS₂ at the bottom is violet.
4. *Sulphides*, S. To 5^{cc} Na₂S sol. add HCl ; put a drop of Pb(C₂H₃O₂)₂ sol. on paper and hold it over the Na₂S sol. as it is heated : black ppt. of metallic luster is PbS.
5. *Nitrates*, NO₃. Mix 5^{cc} NaNO₃ sol. with a little H₂SO₄ and cool it ; then pour down the side of the tube a little FeSO₄ sol. : brown or red ring is (FeSO₄)₂NO.
6. *Sulphates*, SO₄. Add to 5^{cc} Na₂SO₄ sol. BaCl₂ sol. : white ppt. is BaSO₄, insoluble in HCl.
7. *Carbonates*, CO₃. To 5^{cc} Na₂CO₃ sol. add HCl and pass the gas into Ca(OH)₂ sol. : white ppt. is CaCO₃, soluble in excess.
8. *Phosphates*, PO₄. To 5^{cc} HNa₂PO₄ sol. add NH₄Cl sol., NH₄OH and MgCl₂ sol. : white ppt. is MgNH₄PO₄.

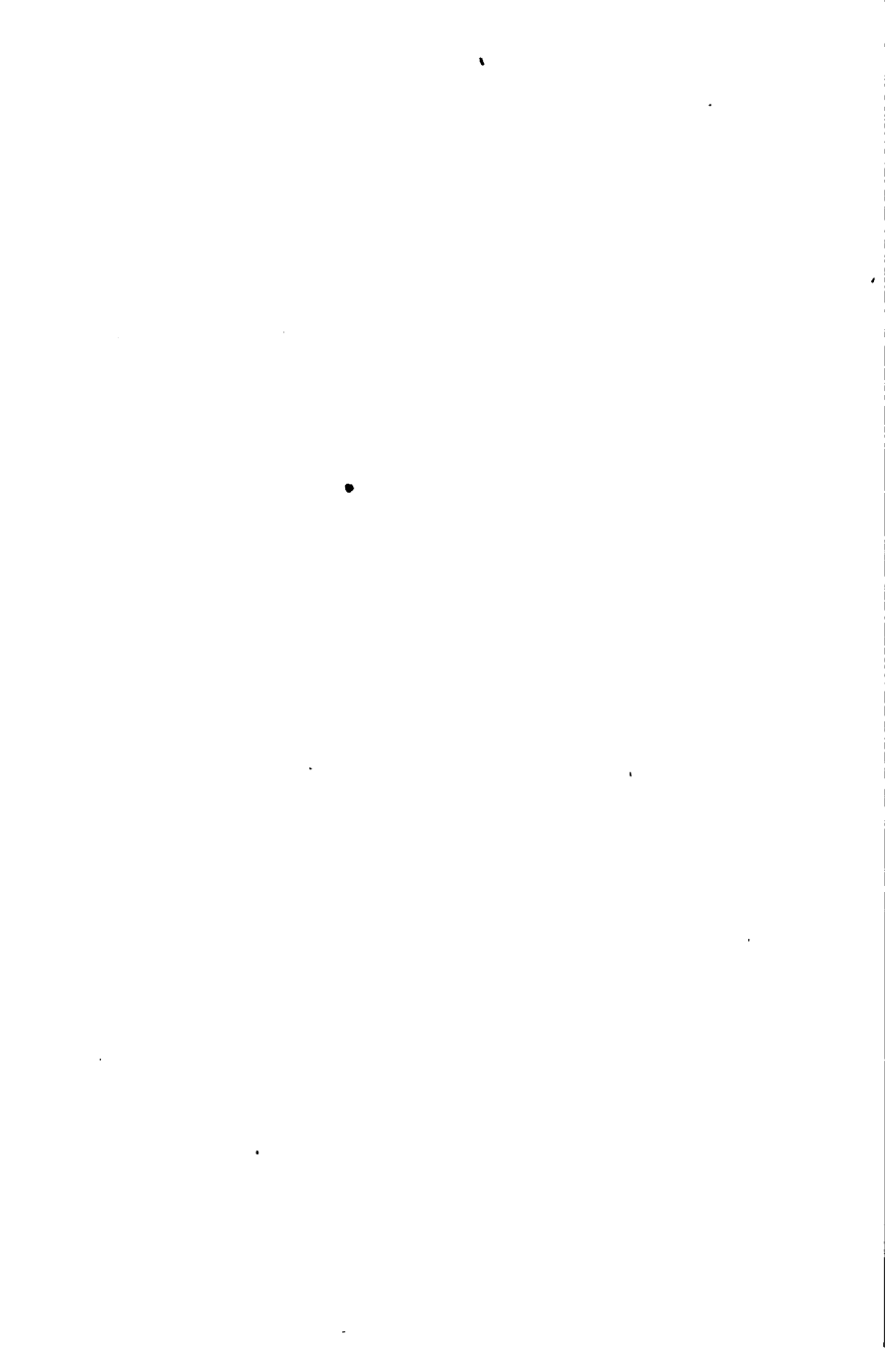


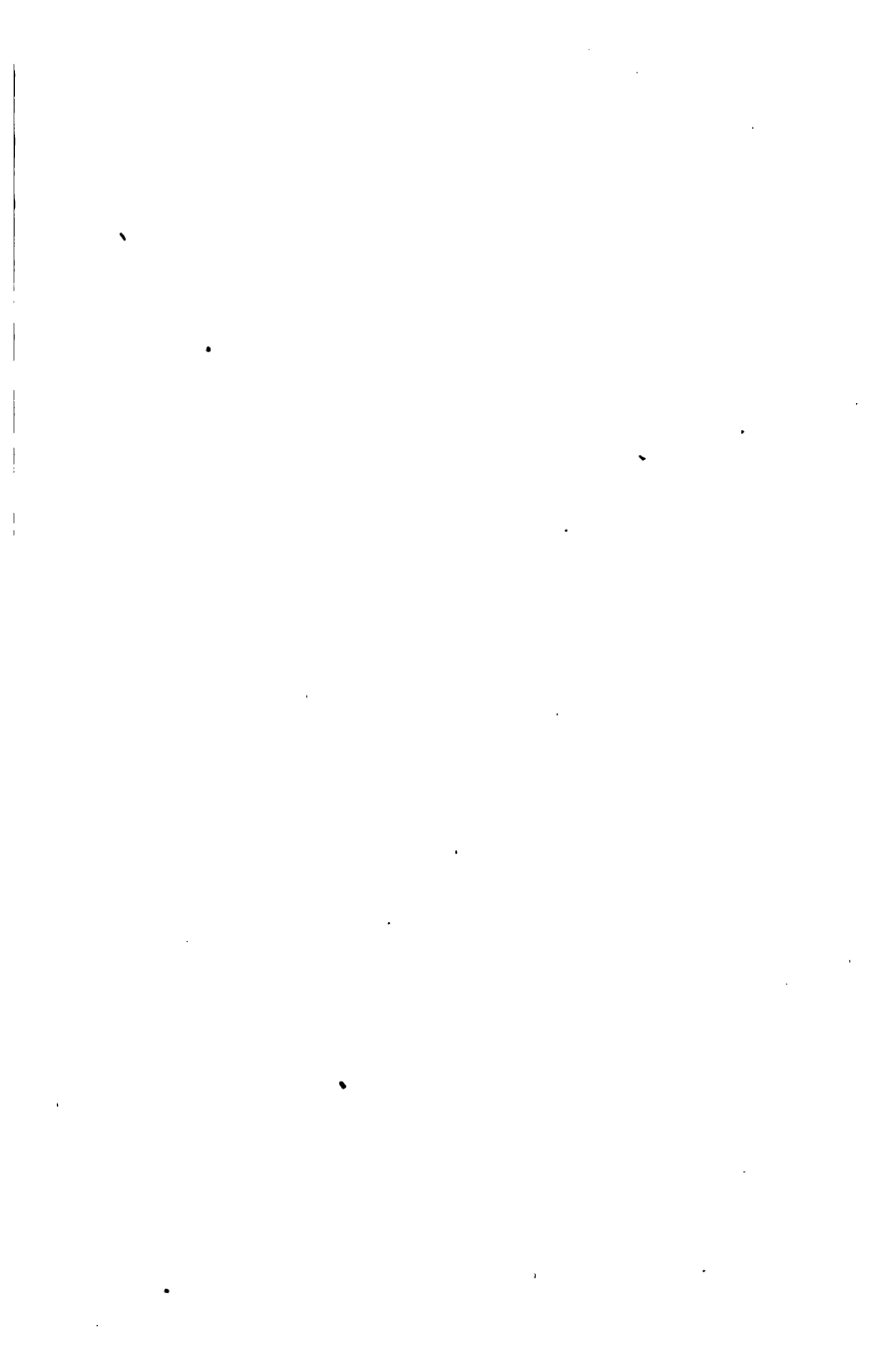


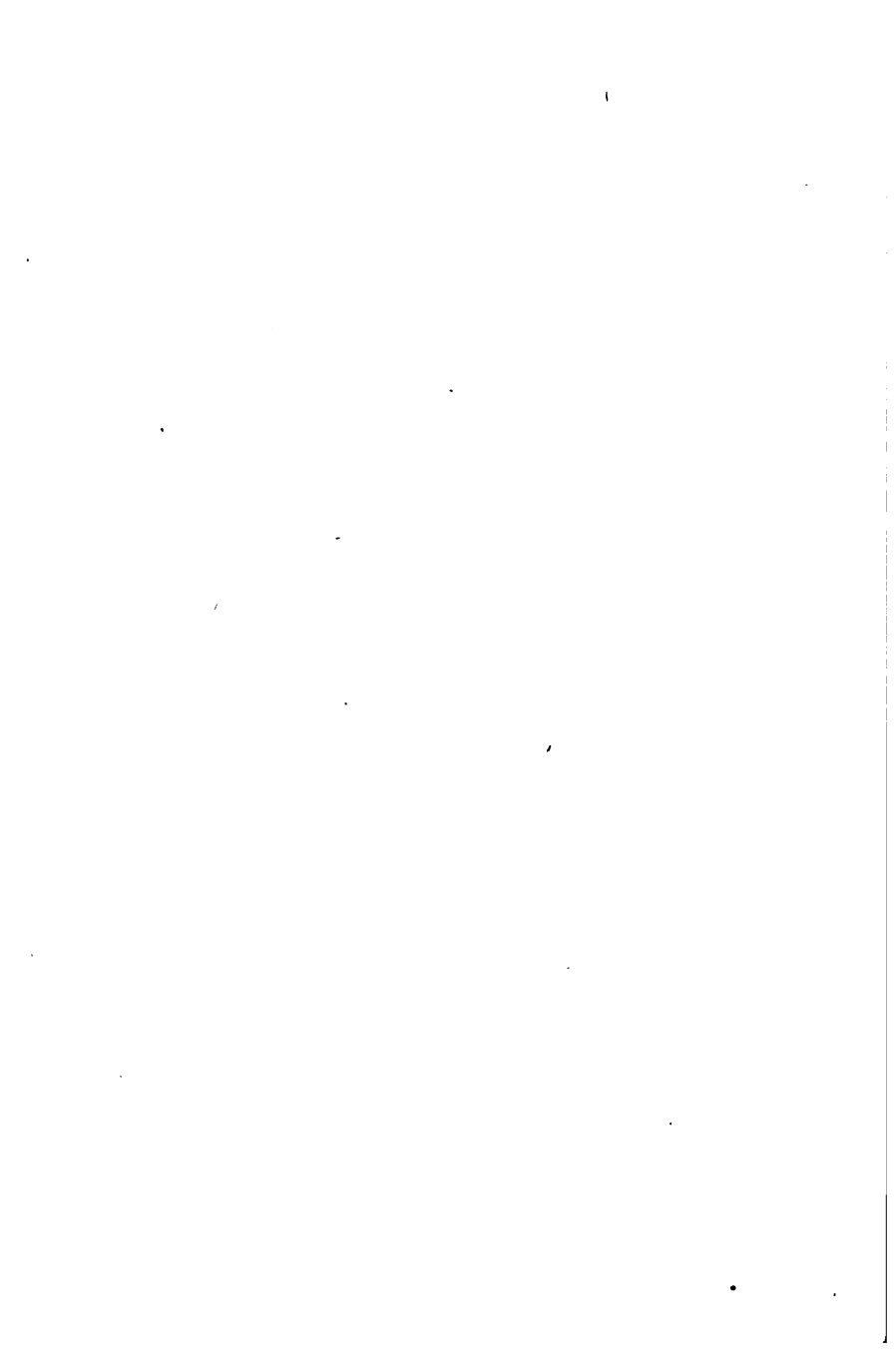


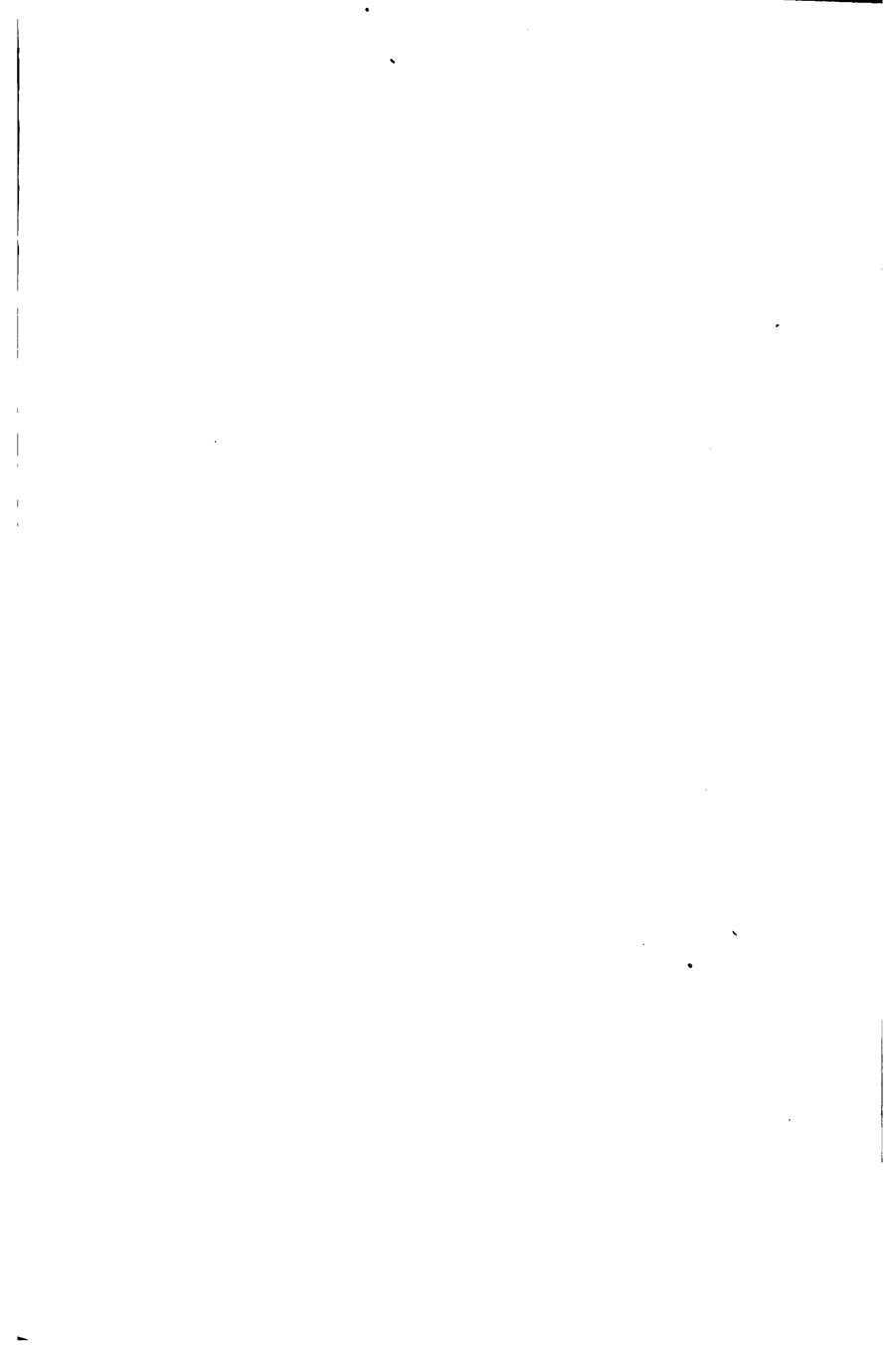












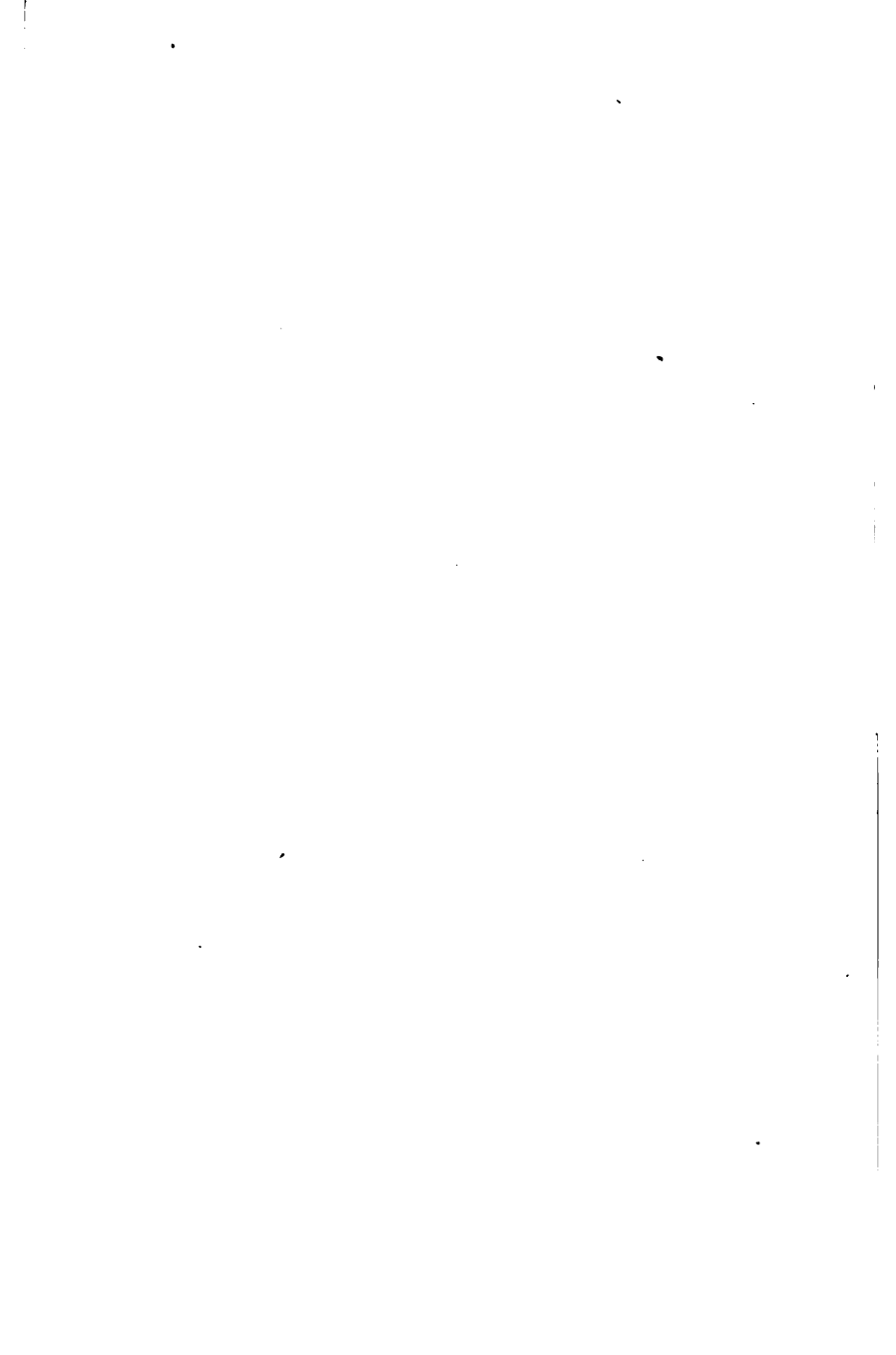
1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that proper record-keeping is essential for transparency and accountability, particularly in financial matters. The text outlines various methods for organizing and storing records, including digital databases and physical filing systems. It also mentions the need for regular audits and reviews to ensure the integrity of the data.

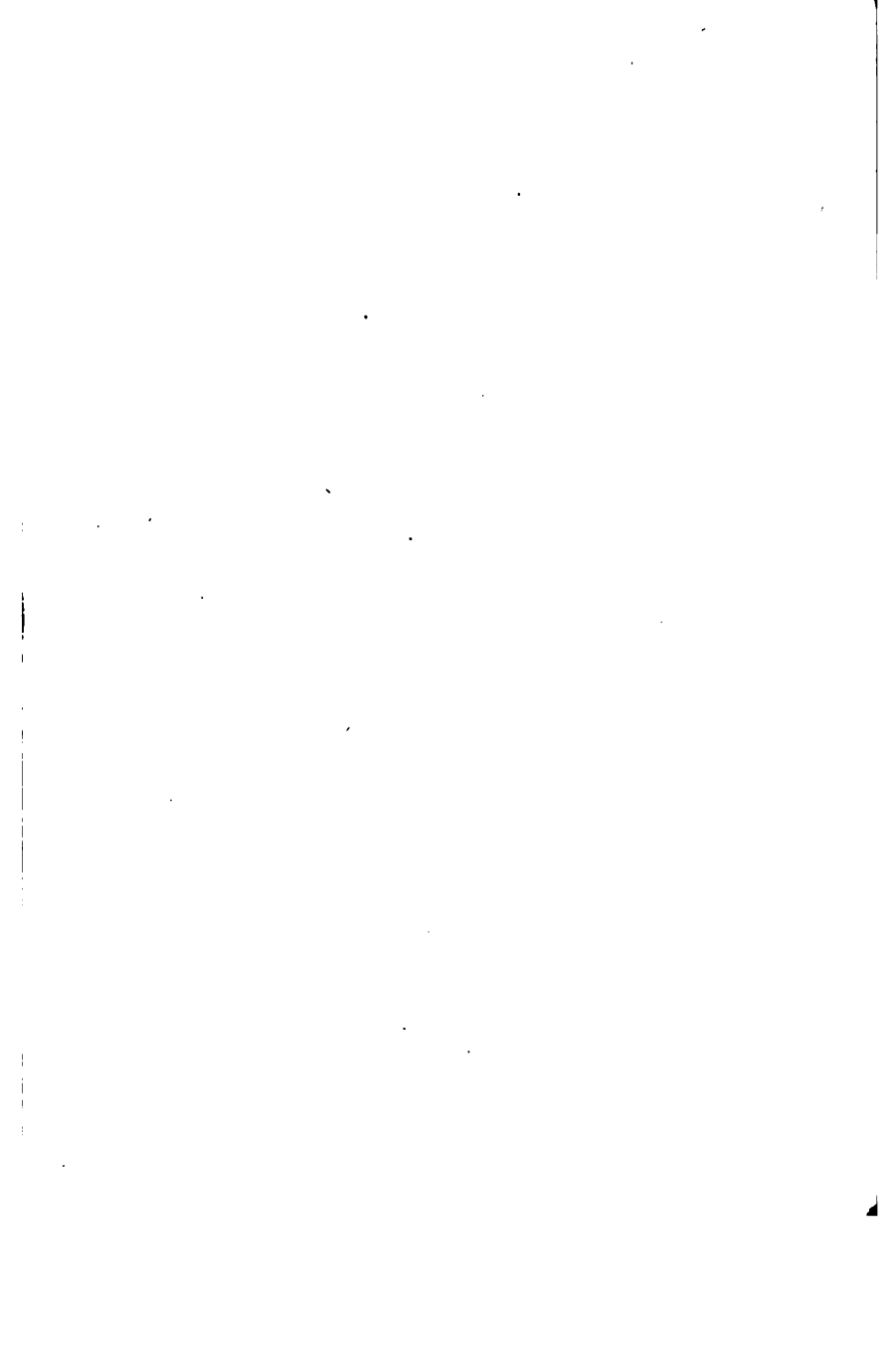
2. The second part of the document focuses on the role of communication in achieving organizational goals. It highlights the importance of clear and concise communication, both internally and externally. The text provides guidelines for effective communication, such as using appropriate language, listening actively, and providing feedback. It also discusses the benefits of open communication, including improved collaboration and decision-making.

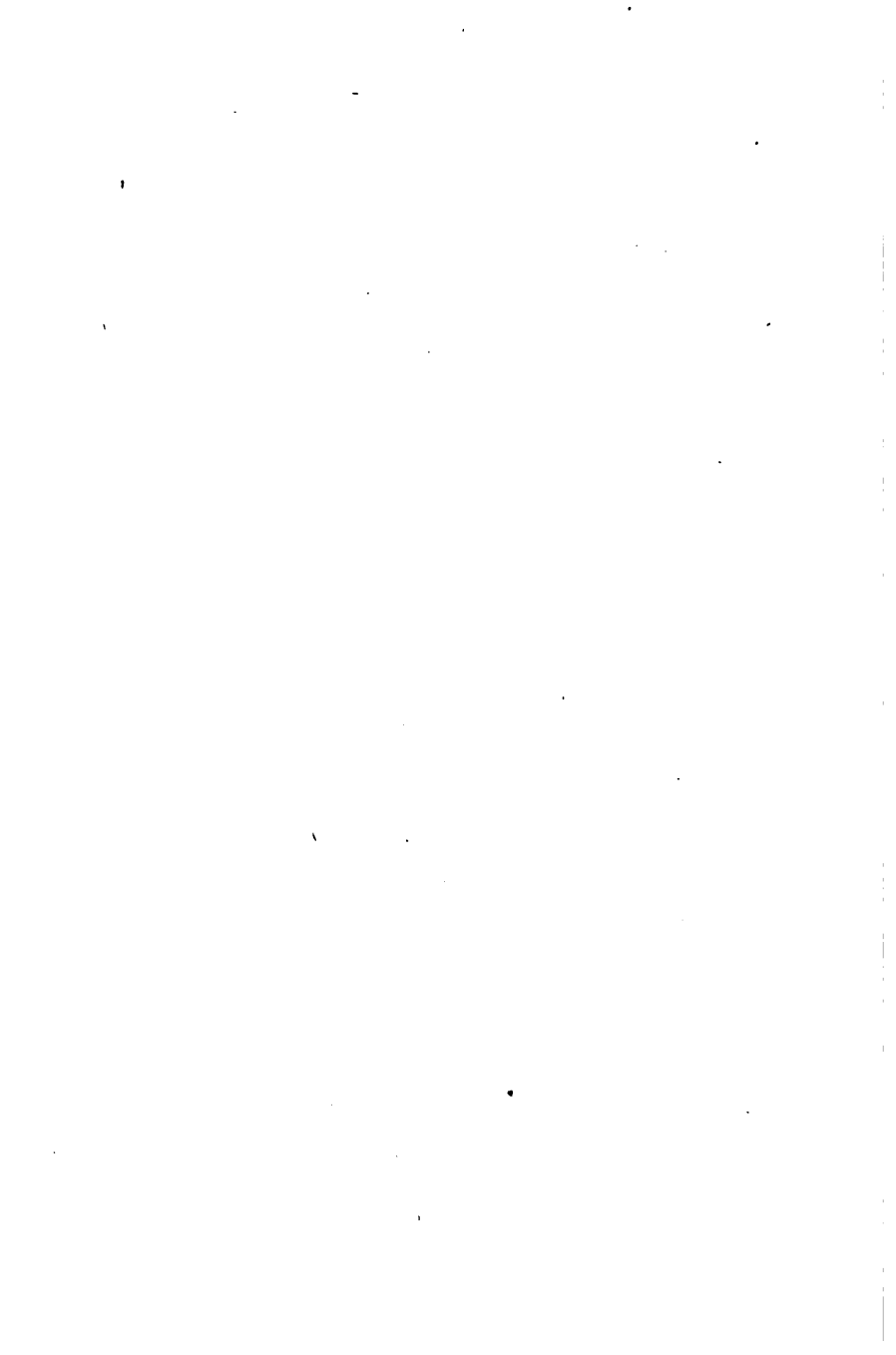
3. The third part of the document addresses the issue of risk management. It defines risk as the potential for loss or damage and explains how to identify, assess, and mitigate risks. The text provides a framework for risk management, including the identification of risks, the assessment of their likelihood and impact, and the implementation of control measures. It also discusses the importance of monitoring and reviewing risks over time.

4. The fourth part of the document discusses the importance of training and development. It emphasizes that ongoing training and development are essential for maintaining a skilled and motivated workforce. The text outlines various training methods, including classroom instruction, on-the-job training, and self-directed learning. It also discusses the importance of setting learning objectives and evaluating the effectiveness of training programs.

5. The fifth part of the document discusses the importance of innovation and creativity. It emphasizes that innovation and creativity are essential for staying competitive in a rapidly changing market. The text provides guidelines for fostering innovation and creativity, such as encouraging open communication, providing resources for experimentation, and rewarding creative ideas. It also discusses the importance of protecting intellectual property and managing innovation risks.







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